THE BIOGEOCHEMISTRY AND PEDOGEOCHEMISTRY OF THE WEST HERCULES AREA, ROSEBERY, WESTERN TASMANIA.

A thesis presented in partial fulfilment of
requirements for the
Degree of Bachelor of Science
with Honours,
University of Tasmania

by

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December, 1976.

FRONTISPIECE: 2400S 300W

Figure: 0.1

A B S T R A C T

Sixteen plant species were sampled over a known pedogeochemical anomaly at West Hercules, Rosebery. This orientation survey was conducted to assess the potential of biogeochemical surveys in the West Coast-type rainforests. Three species were subsequently re-sampled in order to determine the most sensitive plant organ for biogeochemical prospecting.

Both a detailed pilot survey and an independent trial survey proved that young Nothofagus cunninghamii leaves accurately and precisely reflected the soil-lead concentrations. The primary plant-ash data can be enhanced with the use of selected elemental ratios.

A litter survey down five cut grid lines showed that plant-litter has great potential for reflecting elemental concentrations in the soil.

Thirty soil pits were dug and sampled every ten centimetres, both on and off the pedogeochemical anomaly.

The samples came from areas with potential copper, lead and zinc mineralization and analyses have been restricted to these elements and potential scavengers. Chemical analyses for carbon, Cu, Pb, Zn, Ni, Fe and Mn revealed a distinct vertical and horizontal distribution that could be explained by changes in Eh/pH environment and presence of "metal scavengers".

A sequential analysis of the soils indicated which elements were distributed over which soil phases. Copper was sorbed in the clay while lead and zinc were occluded in the iron and manganese oxides.

The organic matter present in the soil complexed iron, manganese, lead and zinc.

The geochemical, pedological and topographic data indicated that the pedogeochemical anomaly at West Hercules was a hydromorphic anomaly formed by seepage of groundwater from the upslope Hercules Host Rocks.

CONTENTS

L I S T O F F I G U R E S

(* - Figures located in Data Volume)

I N T R O D U C T I O N

1.1 LOCATION.

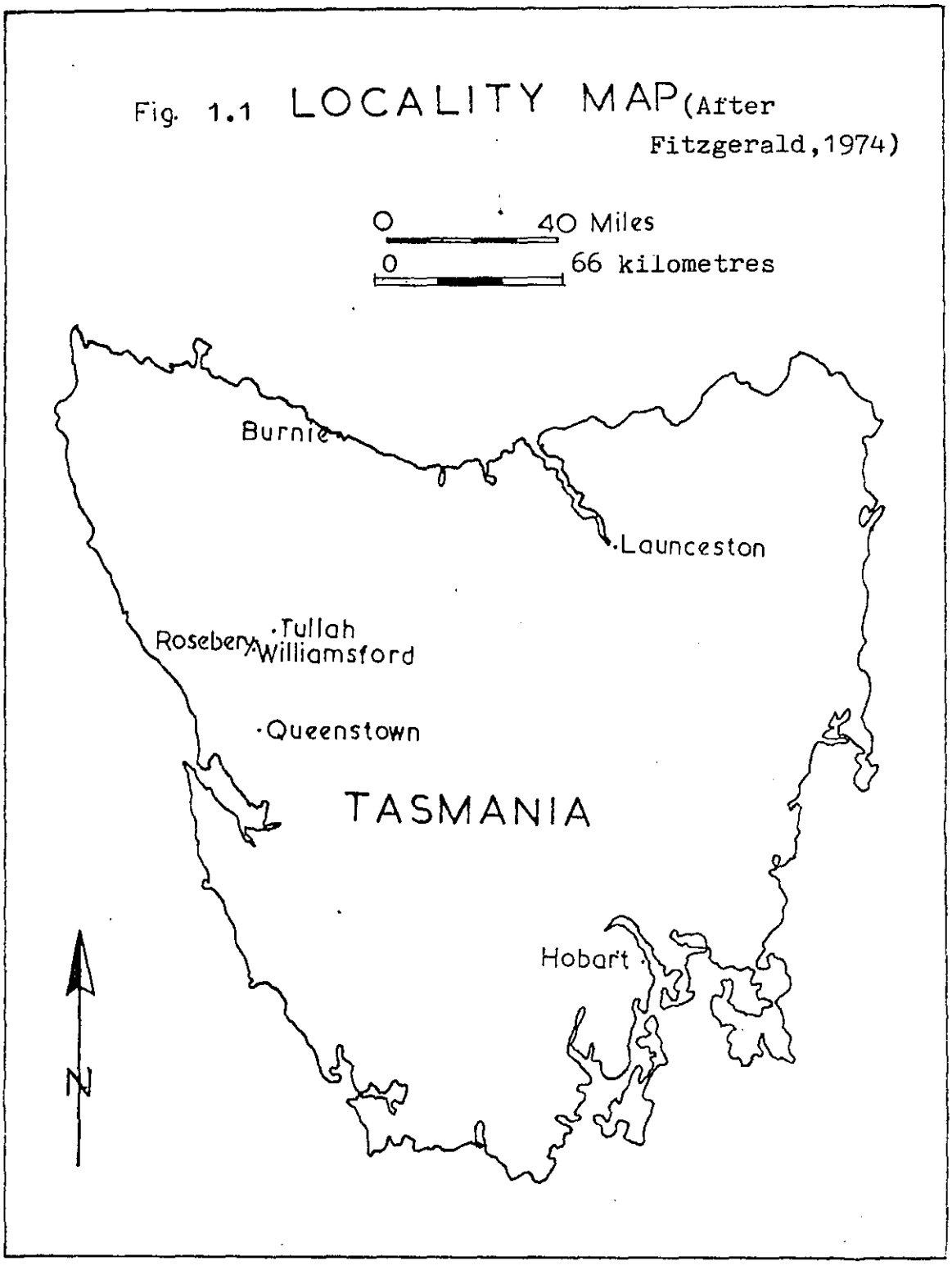
The field work for this project was conducted at West Hercules, south of the haulage and west of the Hercules host rocks (Figure 1.2). The project area is in rugged, steep terrain, dissected by deep valleys. Drainage is generally in a westerly direction from the host rocks of the Hercules Mine, on the western slopes of Mt. Hamilton. This area is 8 km. south of Rosebery and 2.5 km. south-east of Williamsford.

Access to the area is via cut lines from the West Hercules drill access track and the White-Spur track. Grid lines have been cut from 1000E to 2000W and from 2000N to 3000S (Figure 1.5). The higher, steeper slopes which have been previously burnt out, are covered with low resistant grasses and bushes consisting predominantly of Leptospermum nitidum (Tea Tree). Lower down this vegetation merges into virgin rain forest which is predominantly Nothofagus cunninghamii (Myrtle), Anodopetalum biglandulosum (Horizontal) and Atherosperma moschatum (Sassafras), associated with Athrotaxis selaginoides (King Billy Pine).

1.2 PREVIOUS WORK.

The Electrolytic Zinc Company had conducted a geochemical and geophysical exploration programme in the West Hercules area. This programme resulted in the delineation of a strong linear lead-soil anomaly. Subsequently two diamond drill holes (WHP 192 and WHP 193) were drilled but they produced no evidence of mineralization.

Fig. 1.1 LOCALITY MAP (After Fitzgerald, 1974)



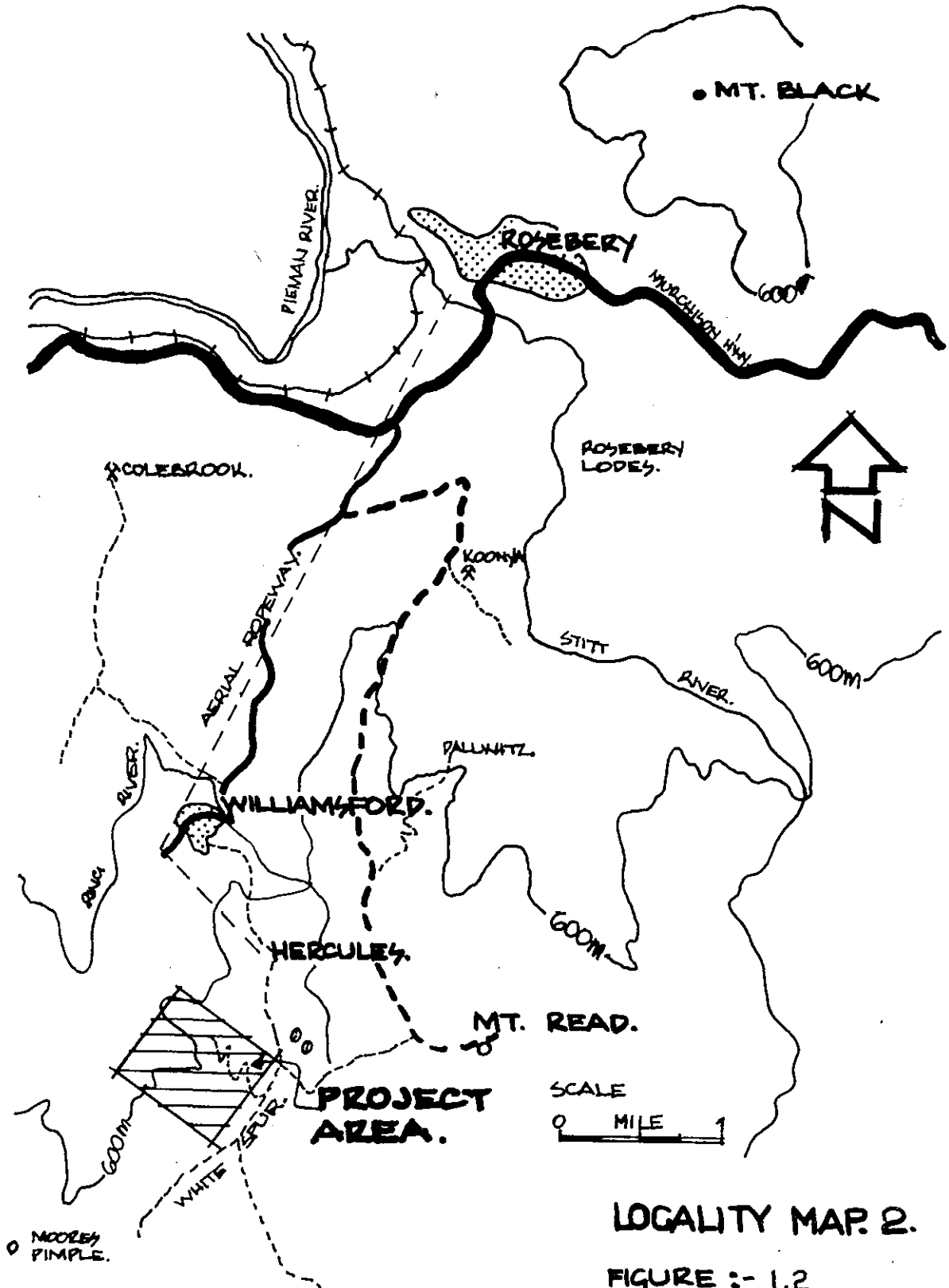
Previous work in this area has been conducted by Reinhardt (1973), Williams (1974) and Stone (1975). The geochemical and geological variations in the adjacent Rosebery Host Rock Horizon were investigated by Eastoe (1973), and Fitzgerald (1974) mapped the adjacent Primrose Pyroclastics.

1.3 GEOLOGICAL SETTING.

The Mt. Read Volcanics of the Hercules Mine area have been divided into two distinct lithological assemblages, the Mt. Black Volcanics and the Primrose Pyroclastics, (Brathwaite, 1969). In the mine area the Primrose Pyroclastics can be subdivided into the hanging wall Massive Pyroclastics, tuffaceous and sedimentary host rocks, and footwall siliceous ash flow tuffs (Fitzgerald, 1974).

These highly siliceous ash flow tuffs of the footwall type are the dominant lithology encountered in the West Hercules Area. They contain lenses of fine grained sediments often interbedded with tuffs (Stone, 1975).

There are two main types of siliceous ash flow tuffs which occur within the area. The white, highly siliceous, fine grained, schistose crystal-tuff occurs directly west of the host rock. It contains some fiamme, "augen" of carbonate (sometimes replaced by mineralization), and crystals of albite. The green, medium to coarse grained, sericite crystal-tuff occurs further west and is more massive in character. For a more detailed discussion on the stratigraphy and lithology of this area, the reader is referred to Fitzgerald (1974) and Solomon and Green (1976).



LOCALITY MAP 2.

FIGURE :- 1.2

RE-DRAWN FROM W.C.M. GEOLOGY DEPT.
ZD. 14. ROSEBERY.

1.4 SCOPE OF THE INVESTIGATION.

This project involved a detailed study of the geochemical soil anomaly at West Hercules and can be divided into two main sections.

(a) The first section investigated the bio-geochemical reflection of the soil anomaly. The species best suited for optimum results were determined and various methods of data enhancement were studied.

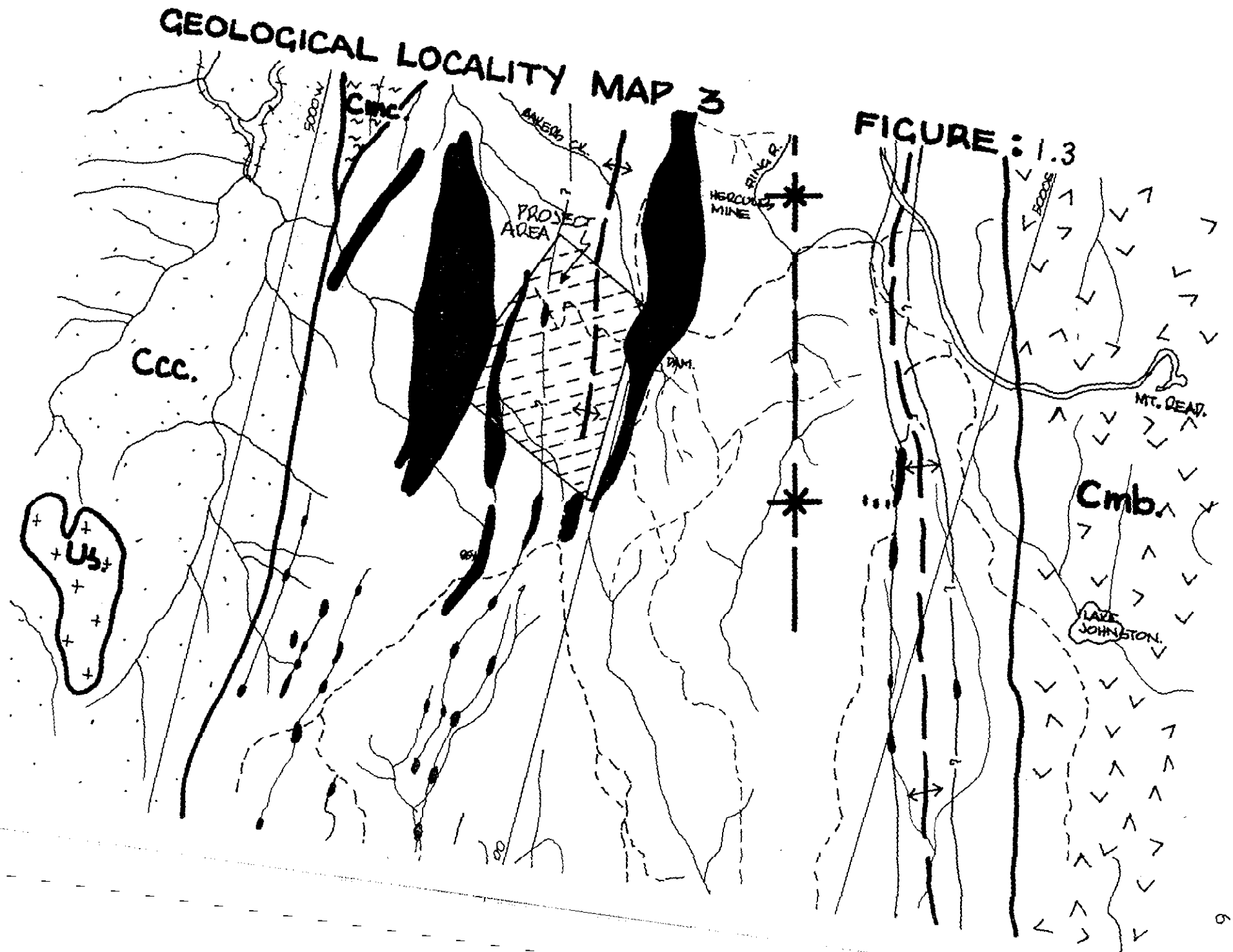
(b) The other section discussed the pedogeochemistry of the lead anomaly. In particular, the horizontal, vertical and chemical distribution of the metals within the soils were investigated.

The ultimate aims of the project were to determine the feasibility of biogeochemical sampling and the reason for the existance of the pedogeochemical anomaly.

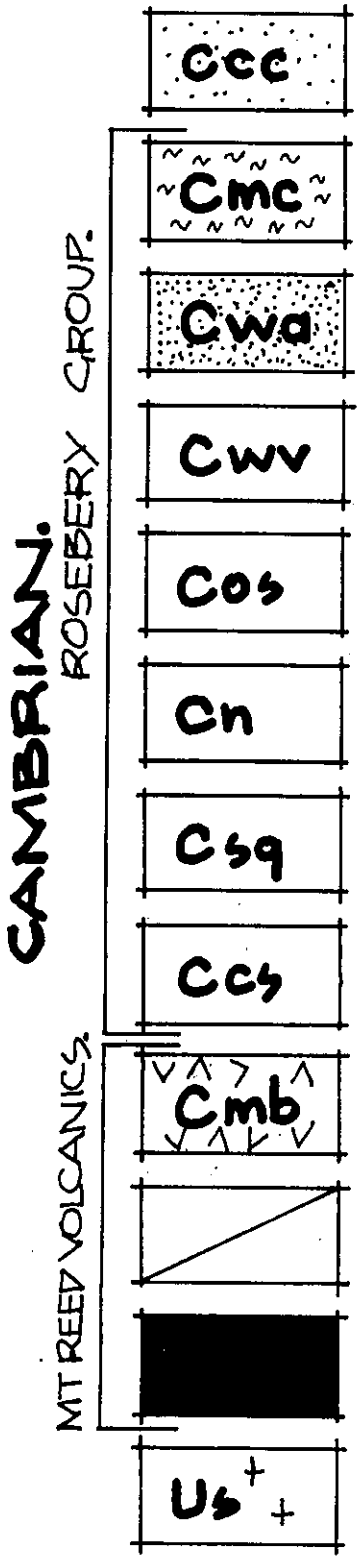
It was with reluctance that the reference grid measurements for the project area were not converted to metric units. Conversion would have negated the numerous cross-references in E.Z. Company files and records of locations within this imperial grid listed in company literature. In addition, further confusion would have arisen as the imperially spaced grid lines (every 200 feet) would not be as conveniently named.

As this project is strongly field-data orientated, the emphasis has been on the first-hand data rather than on a second-hand literature survey. As such, the number of references discussed and referred are kept to a minimum.

This thesis consists of two volumes; a text volume and a data volume. The latter volume contains the raw data, soil descriptions and photographs.


GEOLOGICAL LOCALITY MAP 3
FIGURE : 1.3
Cmc.
Ccc.
PROJECT AREA
HERCULES MINE
RING R.
DAM.
MT. READ.
Cmb.
LAKE JOHNSTON.
Us.

KEY.



CRIMSON CK. ARGILLITE.

MUNROE CREEK SLATE.

WESTCOTT ARGILLITE.

WILLIAMSFORD VOLCANICS.

SALISBURY CONGLOMERATE.

NATONE VOLCANICS.

STITT QUARTZITE.

CHAMBERLAIN SHALE.

MT. BLACK VOLCANICS.

PRIMROSE PYROCLASTICS.
FOOTWALL / HANGINGWALL.

PRIMROSE PYROCLASTICS.
SEDIMENTARY LENSES.

SERPENTINITE.

SCALE.

FIGURE : 1.4

1.5 ACKNOWLEDGEMENTS.

The author gratefully acknowledges the generous financial support of the Electrolytic Zinc Company, West Coast Division. The Company provided accommodation and transport for the duration of the field work and paid for a large proportion of the analyses.

The co-operation and help given by Mr. S. Harding (Chief Chemist, E.Z. Laboratories, Rosebery), was deeply appreciated. The use of the laboratories at Rosebery, made so much more of the sample preparation and subsequent analytical work possible.

Gratitude is also expressed to the Chief Geologists (Mr.C. J. Burton and Mr. G. Dunbar) for their active support of the project. Discussions in the office and in the field with the geologists at E.Z. (Mr. C. G. Stone and Mr. R. Williams) were particularly helpful.

The assistance and encouragement received from Dr. J. C. Van Moort, (University of Tasmania), throughout the project was much appreciated and regarded as invaluable.

The identification of plant species by Dr. J. B. Kirkpatrick (University of Tasmania) and Mr. D. Bradley (New Norfolk High School) is also gratefully acknowledged.

The author also wishes to thank the following for their assistance and support: Mr. P. Robinson (University of Tasmania); Mrs. P.Green (University of

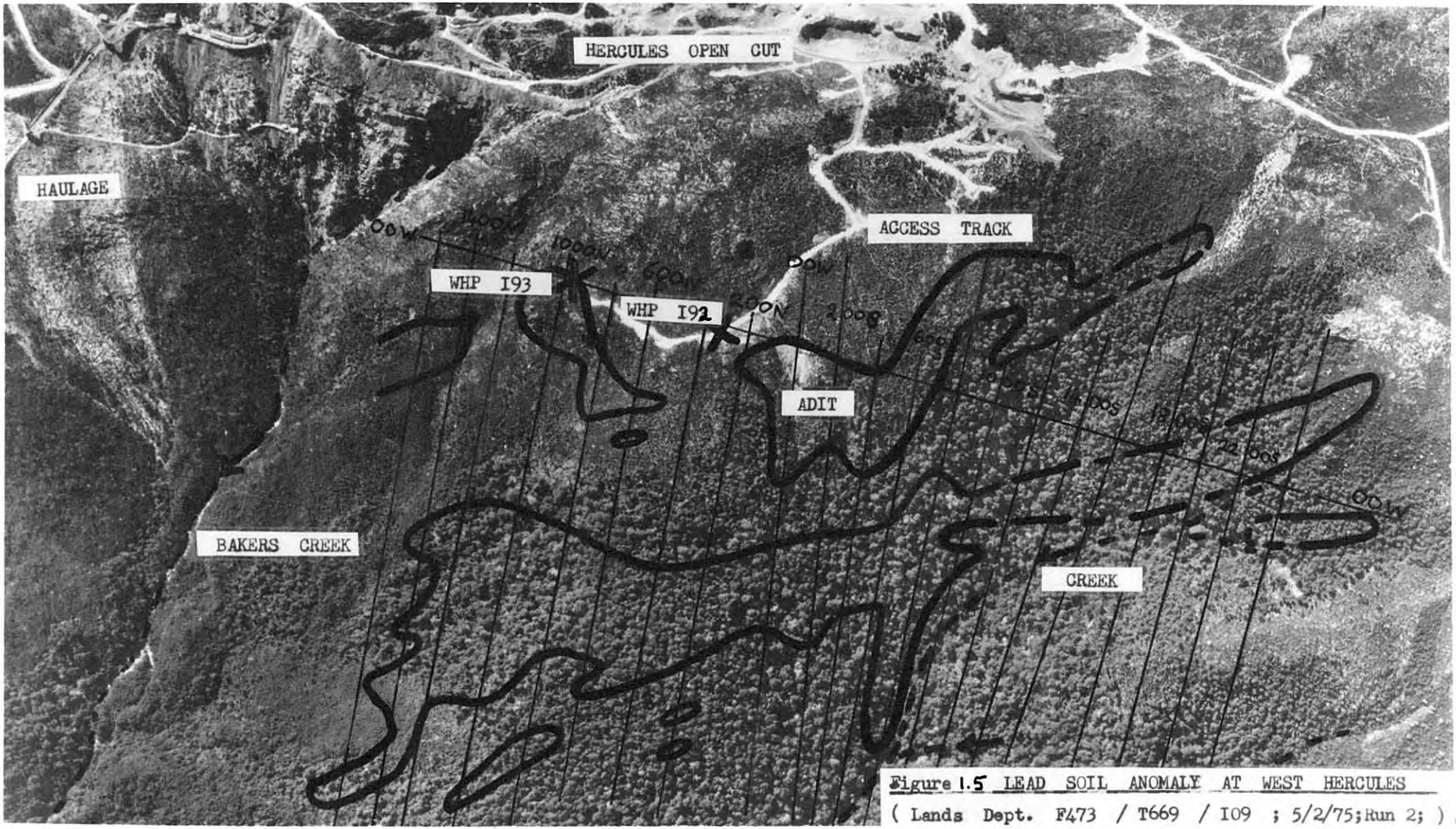


Figure 1.5 LEAD SOIL ANOMALY AT WEST HERCULES

(Lands Dept. F473 / T669 / I09 ; 5/2/75; Run 2;)

Tasmania); Mrs. B. Reid (New Norfolk); Mr. R. C. Begent (Launceston); Mr. J. Russell (Agricultural Department, Launceston); Mr. N. J. Hale (Hobart); Mr. B. Kennedy (Launceston) and his professional colleagues at New Norfolk High School and Tangara House.

B I O C E O C H E M I S T R Y

2.1 INTRODUCTION.

(i) General Theory.

The potential value in the chemical analysis of vegetation liesin the fact that the root system does sample a large volume of soil. Hence, analysis of vegetation samples can reflect the elemental soil concentration values and possible buried mineralization. Unfortunately there are many problems associated with vegetation surveys both in sampling and interpretation of results. Such factors are discussed in following sections.

The elements are extracted from the soil by the roots acting as sampling agents. They obtain aqueous solutions from moist soil which are a potential source of ore-associated metals. Thus elements of interest for exploration must exist in a readily available form for uptake by the root system.

Of the three main mechanisms of absorption of ions by plants two involve uptake by the root system. The third minor mechanism, involves the aerial sections of the plant. (Levinson,1974).

The metals in the aqueous soil solutions either diffuse into the root system or are involved in cation exchange at the surface of clay minerals. The most important of the two processes is cation exchange, in which the carbon dioxide produced by respiration reacts with water to liberate hydrogen ions at the root tips. These ions exchange with cations

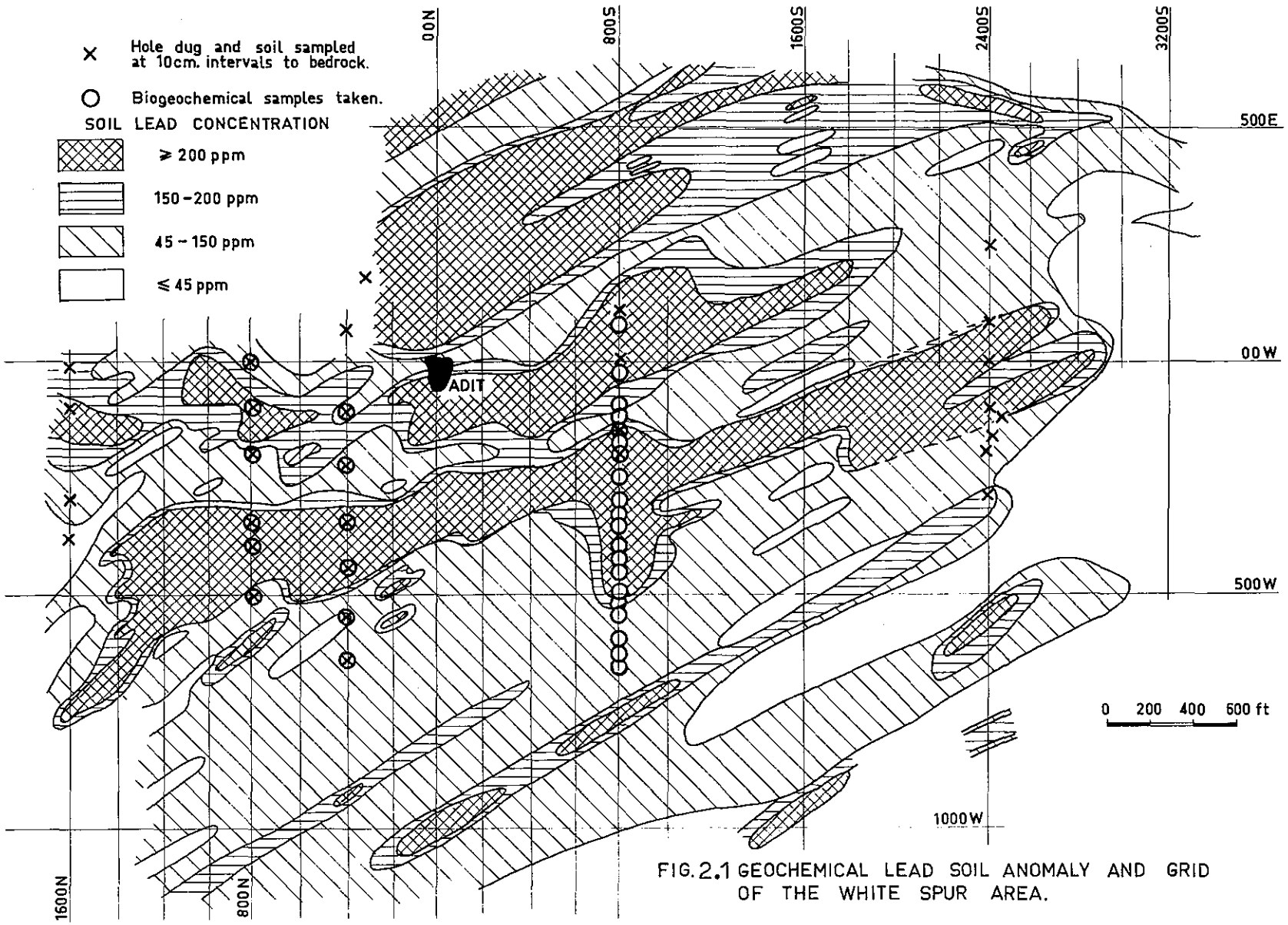


FIG. 2.1 GEOCHEMICAL LEAD SOIL ANOMALY AND GRID OF THE WHITE SPUR AREA.

adsorped on the clay minerals. At the root tip, the cations are again replaced by hydrogen ions and the cycle is repeated (Keller and Frederickson, 1952).

Following their absorption at the root tips, the metal ions are translocated in an upward direction, usually towards the leaves. Obviously a vital factor in biogeochemistry is the availability of elements present in the soil. This is influenced by a large number of factors including pH, Eh, drainage, clay minerals, complexing agents and the antagonistic effects of other ions. (Brooks, 1972).

(ii) Scope of the Biogeochemical Investigation.

This section of the project investigates the possibility of using biogeochemistry in mineral prospecting on the West Coast of Tasmania. Methods and specific difficulties of sample collection and preparation are discussed.

Two orientation surveys were conducted. One in order to determine the most useful species, the second to determine the most useful organ for the reflection of elemental soil values. These surveys were followed by a detailed pilot vegetation survey across the soil anomaly, using the species and plant organs proved to be the most effective. This was followed up by a trial survey in a different location, across the soil anomaly. This trial survey effectively checked the accuracy and reliability of the plant species chosen.

The possibility of using litter to reflect the soil anomaly was investigated in the form of litter survey

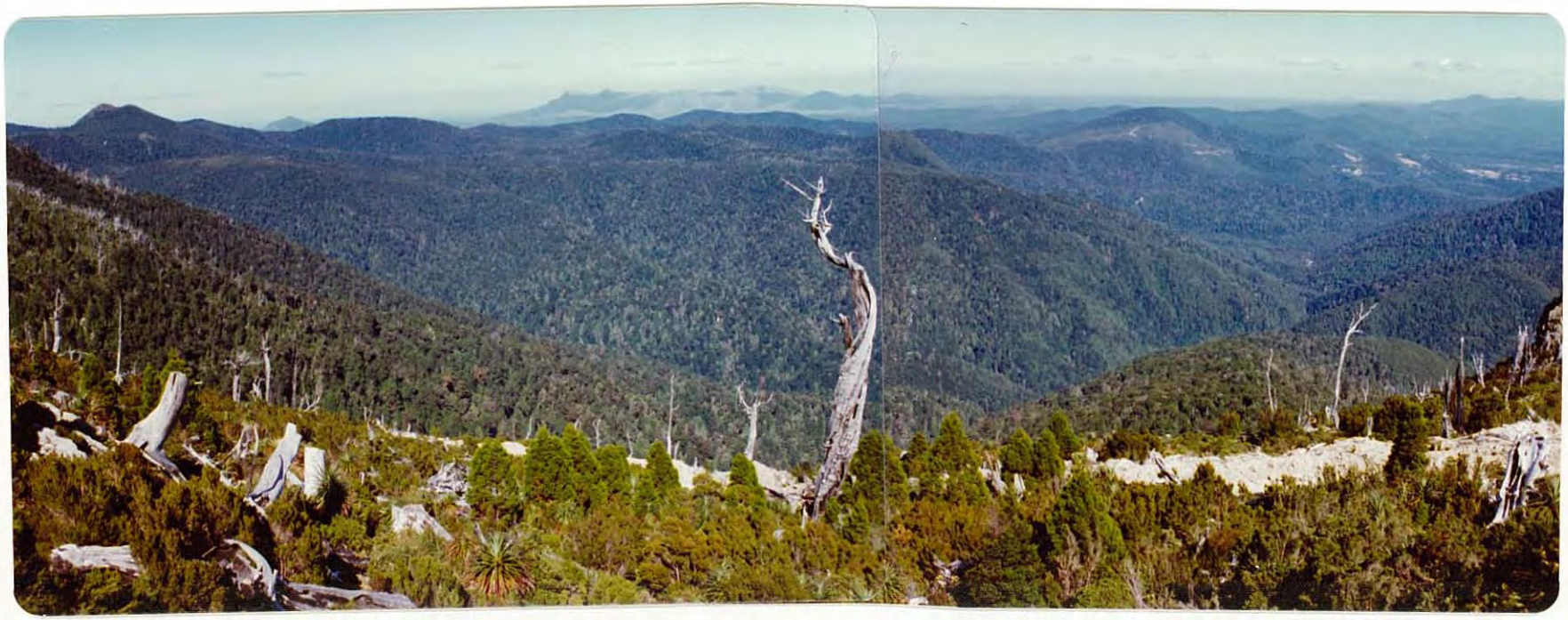


Figure:2.2 Overlooking West Hercules Project Area (Facing West) Looking down line 400N (centre-right)

across the geochemical soil anomaly.

(iii) Project Area Description.

An intensive geochemical soil survey had been previously conducted in the West Hercules Area by the E.Z. Company. This had resulted in the delineation of a distinct linear,lead-soil anomaly. (Figure 2.1). It was the aim of this investigation to determine the feasibility of biogeochemistry in reflecting this existing soil anomaly.

The project area is in rugged terrain, dissected by deep valleys. (Figure 2.2). The higher steep slopes, (often showing evidence of having been burnt out), are covered with low resistant shrubs, bushes and grasses. (Figure 2.3). This vegetation is predominantly Leptospermum nitidum (Tea Tree). Lower down, the vegetation merges into virgin rain forest which is predominantly Nothofagus cunninghamii (Myrtle), Anodopetalum biglandulosum (Horizontal), and Atherosperma moschatum (Sassafras) associated with Athrotaxis selaginoides (King Billy Pine). (Figure 2.4). The table on page 20 (Figure 2.5) lists the twenty three species collected which were subsequently identified by Dr. J. Kirkpatrick (Geography Department, University of Tasmania) and Mr. D. Bradley, (New Norfolk High School).

Figure: 2.3 Project Area; looking across 00W from 400N, showing vegetation change from upper to lower slopes.

2.2 SAMPLE COLLECTION.

(i) Sample Location.

The E.Z. Company had established an exploration grid (measured in feet) of cut lines in the West Hercules Area for their initial geochemical soil sampling, (Figure 1.5). This grid proved invaluable in obtaining vegetation and soil samples for the project. Vegetation sampling was confined to three well-spaced cut lines (800N, 400N and 800S) that ran at right angles across the linear soil anomaly, (Figure 2.1).

Sampling for the species orientation survey was conducted down lines 800N (00W to 1000W) and 400N (200W to 1300W) on the 19th January 1975 and 20th January 1975, respectively. Sample collection for the plant organ orientation survey and the detailed pilot survey was conducted down 400N (800E to 1300W) during the week ending 7th June, 1975. Vegetation for the trial survey was collected down 800S (100E to 1300W) on 13th January 1976. The samples used in the litter survey were collected down five cut lines (2400S, 800S, 400N, 800N and 1600N) during the week ending 9th February 1975.

(ii) Species Collected.

As discussed in Appendix A.1, samples of the various plant organs were cut from the trees with secateurs and sealed in prenumbered plastic bags. Each sample consisted of between 100 and 200 g. These were transported back to the laboratory where, within four to five days, they were carefully washed in distilled water. This washing was designed to remove any dust or contamination

Figure: 2.4 Project Area; looking down cut grid line 400S from 00W.

from the vegetation. The washed vegetation was spread out on aluminium-foil trays and oven-dried at 90°C. The samples could then be kept for a long period of time in dark, dry, cool storage, sealed in plastic bags.

At any specific location, the samples were collected at various points around the circumference of the plant, at a point as high as could be conveniently reached from the ground. Organs of several plants of the same species were included in each sample collected from any one specific location. Those procedures would tend to reduce the variation of elements in the plant ash due to such variables as aspect, root depth, health and age of plant sampled. In this way, sampling procedures were used to control the effect of some botanical variables on the elemental concentration in plant ash.

In the virgin rain forest, difficulties were experienced in sampling some organs (e.g. leaves and twigs) due to the great height of the trees (Figure 2.6). This was overcome by scaling the respective trees. However, the problem could have been solved by the use of long-handled pruning shears.

The table drawn up of all the species collected from the project area (Figure 25) indicates, by an asterisk, the sixteen species sampled and analysed in the species orientation survey.

PLANT SPECIES IN PROJECT AREA

*Acacia melanoxylon (Blackwood)

*Acacia mucronata

*Agastachys odorata

*Anodopetalum biglandulosum (Horizontal)

*Atherosperma moschatum (Sassafras)

*Cenarrhenes nitida (Native Plum)

*Coprosma nitida

*Cyathodes juniperina

Drimys lanceolata (Skunk Blackwood, Mountain Pepper).

Eucalyptus obliqua

*Eucryphia lucida

*Gahnia grandis (Cutting grass)

Gaultheria hispida (Snow Berry)

*Leptospermum nitidum (Tea Tree)

*Microsorium diversifilium (Fern)

Monotoca elliptica

*Nothofagus cunninghamii (Myrtle)

*Olearia alpina

*Olearia phlogopappa (Dolly wood)

Oxylobium arborescens

*Persoonia gunnii

Phebalium squameum (Satin wood)

Pteridium esculentum (Fern)

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* - Plant species sampled for Biogeochemical Orientation Survey.

Figure: 2.5

Figure: 2.6 Cut Grid Line 800S; just inside the Nothofagus cunninghamii rain-forest.

2.3 SAMPLE PREPARATION.

(i) Discussion of method (for details see Appendix A.1)

Both the washing and oven-drying of the samples were completed at the E.Z. Laboratories, by kind permission of Mr. S. Harding (Chief Chemist, Rosebery). Samples of the distilled water used for washing were taken and analysed by A.A.S. for possible contamination. However, all such contamination testing showed that no contamination had occurred.

The samples were subsequently cut up and ground to a fine powder (less than 1mm). The grinder used was a four bladed, high speed electric "Casella Wheat Grinder" with a 1mm. screen, (Figure 2.7), provided by Mr. J. Russell (Agricultural Department, Launceston).

Approximately 10 g of the powder was placed in a squat 50 ml beaker. This was ashed at 450°C for 8-10 hours producing about 0.5 g of ash. Care was taken to ensure that the ashing temperature did not exceed 450°C, as at higher temperatures, metals of interest would have been lost as volatiles. The ashing was carried out in the presence of a small amount of air. For if too much air was admitted, the material could catch fire. While the presence of too little air increased the chance of volatization of some elements. (e.g. Lead) (Brooks, 1972)

The ashed samples were sent to Australian Laboratory Services, Brisbane, for analysis. Where possible 0.5 g of ash was digested with 20 mls of 10% hydrochloric acid for 1 hour at 180°C. The samples were then analysed by atomic absorption spectrometry for Cu,

Figure: 2.7 Electric, High Speed, rotary "Casella" Wheat Grinder", used for grinding vegetation samples.

Pb, Zn, Ni, Fe, Mn, Cd and Ba.

(ii) Prospective Pitfalls in Preparation.

In the preparation of vegetation samples, there are a few pitfalls for the unwary worker. The samples must be completely dried, otherwise the screen of the grinder soon becomes blocked.

Wood, bark and twig samples should be cut before being dried, otherwise the cutting up of samples before grinding can become extremely tedious. Difficulty was experienced in grinding wood and bark samples and great care had to be taken in order to avoid damaging the grinder.

When the samples are being ashed, care needs to be exercised to ensure complete ashing, otherwise inconsistent results would ensue.

(iii) Analytical Precision.

Periodically within a batch, samples were resubmitted as a check for laboratory precision and possible contamination. The results for these check samples (Figure 2.8) indicated that the precision for Cu, Pb, Zn and Cd analyses was good. The precision for Ni and Mn analyses was generally acceptable while in only one out of the four cases, the precision for Ba and Fe analyses was acceptable (i.e. variation less than 20% of the larger value).

CONTAMINATION AND PRECISION TESTS ON BIOGEOCHEMICAL ANALYSES

(ppm)

No.	Cu	Pb	Zn	Ni	Mn %	Fe%	Cd	Ba
543	280	540	560	35	4.2	0.21	10	680
543	290	450	580	30	4.3	0.20	15	250
Variation	3%	17%	3%	14%	2%	5%	(33%)	63%
582	390	700	0.18%	190	4.0	0.44	35	600
614	330	620	0.17%	35	3.5	0.22	40	500
Variation	15%	11%	6%	82%	13%	50%	13%	17%
634	330	400	0.39%	45	3.9	0.19	25	980
654	350	320	0.29%	45	1.75	0.12	20	460
Variation	6%	20%	23%	0%	55%	37%	(20%)	53%
615	540	260	0.15%	70	0.58	0.44	20	320
653	560	185	0.14%	50	0.54	0.26	15	450
Variation	4%	29%	7%	29%	7%	41%	(25%)	34%

(x%) ≡ Variation not significant as difference of analyses close to detection limit.
Variation expressed as a percentage of higher concentration.

Figure: 2.8

2.4 ORIENTATION SURVEY FOR PLANT SPECIES.

(i) Outline of Method.

The aim of this survey was to determine which plant species were the most effective in reflecting the soil anomaly. Combined leaf/twig samples were taken of sixteen species down two grid lines (450N and 800N) which crossed the soil anomaly. (Figure 2.1). Before the sampling programme commenced, the abundance and distribution of various species were determined. It was important that those plants selected for the survey should be obtainable at most sample sites in the area, otherwise gaps would have occurred in the sampling network.

(ii) Discussion of Results.

The results of the analyses are tabulated in Appendix D.1. The criteria of availability and continuity of the plants reduced to eight, the number of potentially useful species. The elemental concentrations in the plant ash of these species were plotted down the two lines. These plots were then compared with bed-rock and soil values for the respective elements. This comparison indicated which species had the potential to accurately reflect the soil anomaly. Some species were precluded from final selection due to the extreme difficulty of handling them and inconvenience of sample preparation.

The three species thus chosen for more intensive sampling were:-

(a) Nothofagus cunninghamii (Myrtle - Figures 2.9 and 2.10) which occurred right down both grid lines.

(b) Leptospermum nitidum (Tea Tree - Figure 2.11) which

Figure: 2.9 Nothofagus cunninghamii (Myrtle).

An evergreen tree reaching a height of 35-50 m with a diameter of 1.5-2.0 m. At high altitudes it forms a dense shrub.

Leaves are alternate and shortly stalked. The Leaf blade varys from ovate to triangular-rhomboid and is usually 6-18 mm long. The blade is thick, rigid, flat or slightly convex with a coarsely and bluntly crenate-toothed margin. The upper surface is dark green and shining. The leaves of the new shoots in spring are often bright golden-bronze or red and conspicuous against the dark mature foliage.

Flowers occur near the ends of the branches, often on short lateral shoots. It is a common species in Tasmania's temperate rainforests. (Curtis, 1967).

Figure: 2.10 Nothofagus cunninghamii; most successful species sampled for biogeochemical work.

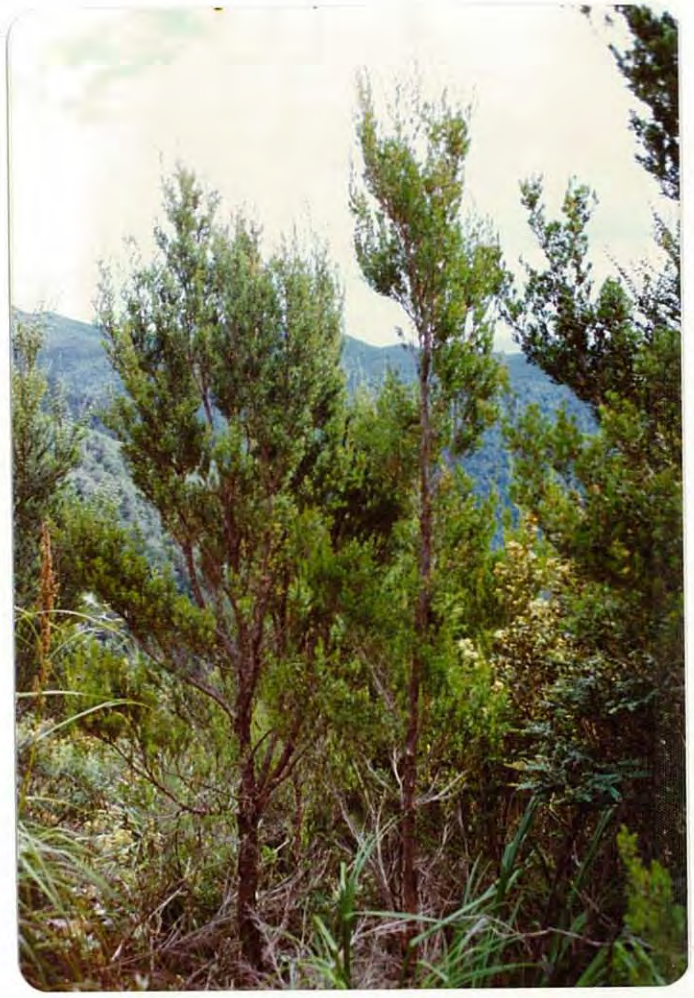


Figure: 2.11 Leptospermum nitidum (Teatree)

A rigid shrub, erect and multiple branched. It is usually 2-4 m high but it can be stunted to a small shrub.

The leaves are suberect, narrow and elliptical with an acute apex. The base of the leaf is narrowed and it is 8-20 mm long. The flowers are 18-26 mm diameter and solitary.

The fruit is silky-hairy during development but the outerwall soon separates. The mature fruit is nearly 1 cm in diameter, hemispherical, with the top almost flat and opening into five valves. (Curtis, 1956).

occurred on the upper slopes.

and

(c) Anodopetalum biglandulosum (Horizontal - Figure 2.12), which grew lower down in the rain-forest.

Figure: 2.12 Anodopetalum biglandulosum (Horizontal)

A slender evergreen tree up to 15 m high. In exposed situations it grows as a bushy shrub. Typically the trunk bends over into a horizontal position and sends up vertical branches which in turn bend over. The inter-tangled trunks and tough branches form a platform several metres above ground-level. As such it forms a dense, almost impenetrable scrub.

Its leaves are opposite each other, short stalked, narrow and elliptical. They are blunt, 2-6 cm long and have a margin with coarse blunt serrations. The flowers are either solitary or occur two or three together on short pedicels. The fruit is fleshy, 6 mm long and one seeded.

The species is endemic in Tasmania occuring in regions of high rainfall in the south and west. In the field area it is locally abundant, sometimes forming an under storey in the temperate rainforest, under Nothofagus cunninghamii. (Curtis, 1956).

2.5 ORIENTATION SURVEY FOR PLANT ORGANS.

(i) Outline of Method.

As there were indications in the initial stages of the species orientation survey that different plant organs concentrated elements to differing degrees, this was investigated. Individual trees of the three selected species were analysed for Cu, Pb, Zn, Fe, Mn, Ni, Ba and Cd in bark, wood, old and young twigs, and leaves. Samples of these organs were taken from both the base and the apex of the individual trees. (Brooks, 1972)

The aim of this survey was to determine the most effective organ for detecting various elements in the soil. The survey was also designed to indicate whether it was more advantageous to sample organs from the base or apex of the trees. In the case of Nothofagus cunninghamii a young tree (2.5 m high) and a more mature tree (6m high) were sampled.

The sample sites were selected to coincide with pits that had been dug and sampled for soil and bedrock. This gave an indication of the relative concentration powers of the various organs of different ages. The two sample sites were (400N, 480W) and (400N, 700W), the latter being on the lead soil anomaly, the former being above it.

The relative concentration or preferential enrichment of certain elements by plants is known as the Goldschmidt enrichment principle. The ratio of the concentration of an element in plant ash to its concentration in the soil is termed the enrichment

co-efficient or relative concentration. This is a measure of the biogenic characteristics of that element (Brooks, 1972). A biogenic element either has a physiological role or else it has been accumulated without requirement and is known as a ballast element. Brooks (1972) assumes that elements with an enrichment co-efficient of 0.10 or greater are biogenic and those with co-efficients less than 0.01 are nonbiogenic. Those elements with co-efficients between 0.10 and 0.01 are intermediate elements.

(ii) Discussion of Results.

The analytical data (Appendix D.1) for each species is plotted on histograms (Figures 1.13 to 1.16). The elemental concentration in the plant ash is given on the vertical axis with the plant organs arranged along the horizontal axis. This axis is divided into two sections, one containing organs from the bottom or base of the tree, the other containing organs from the top or apex.

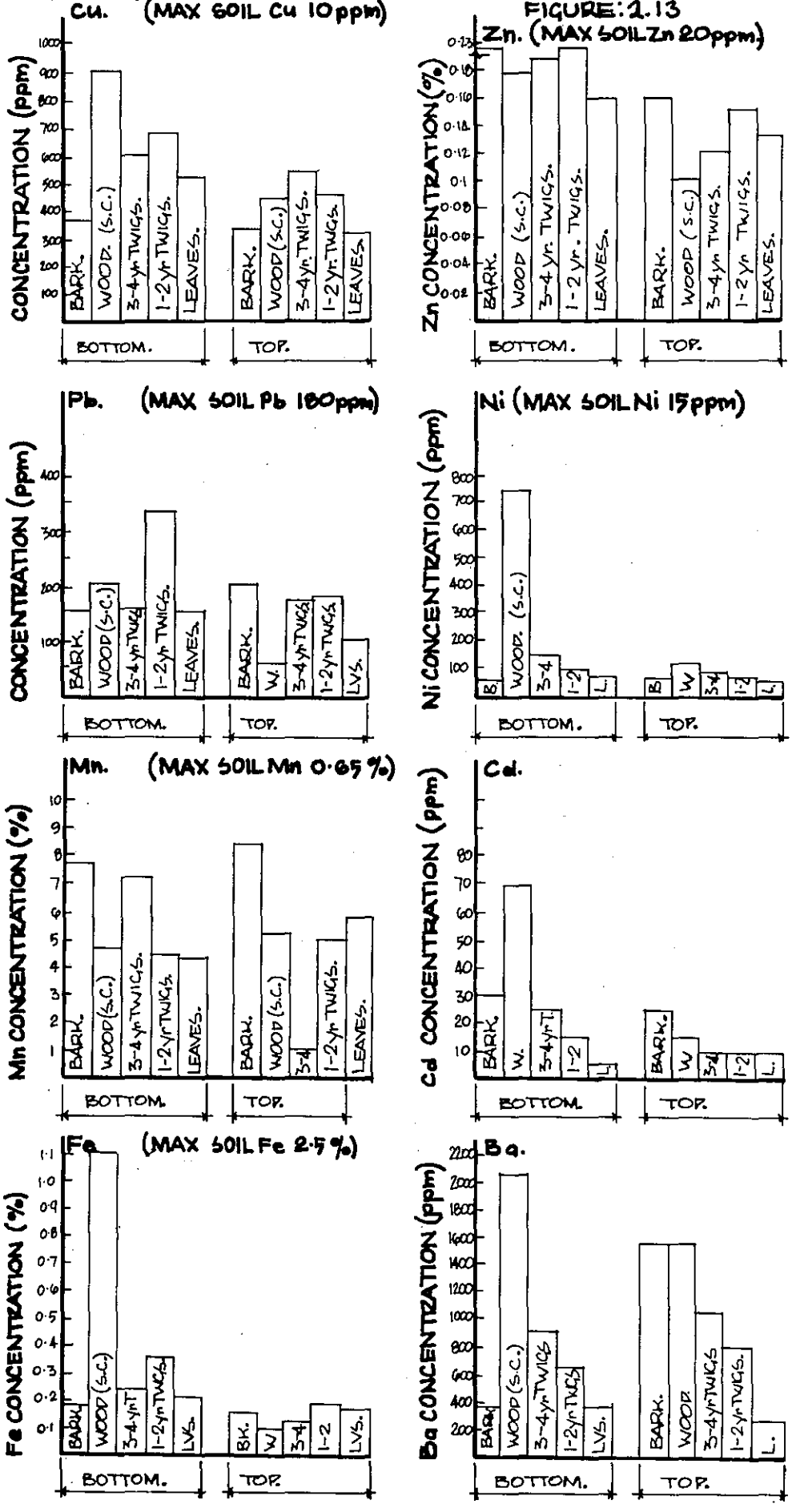
The organs are arranged in the following order:- bark, wood, old twigs, young twigs, and leaves. In the graphs, the postscript (S.C.) for wood indicates that it was saw-cut. The maximum soil concentration around the base of the plant is given for comparison of the relative concentration power of the various organs. (i.e. enrichment co-efficient)

(a) Element Distribution in Nothofagus cunninghamii Organs (Figures 2.13 and 2.14).

Copper is most effectively concentrated by

ELEMENT DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ORGANS. TREE HEIGHT 2·5m POSITION 400N 480W

FIGURE: 2.13



the wood and then by the twigs. Generally the younger twigs contain greater amounts of copper. At the base of the tree, the leaves contain more copper than does the bark, however this trend is reversed at the apex. The wood, twigs and leaves contain greater amounts of copper at the base of the plant than at the apex. In all cases copper is strongly concentrated by the plant organs, with an enrichment co-efficient of between 50 and 80.

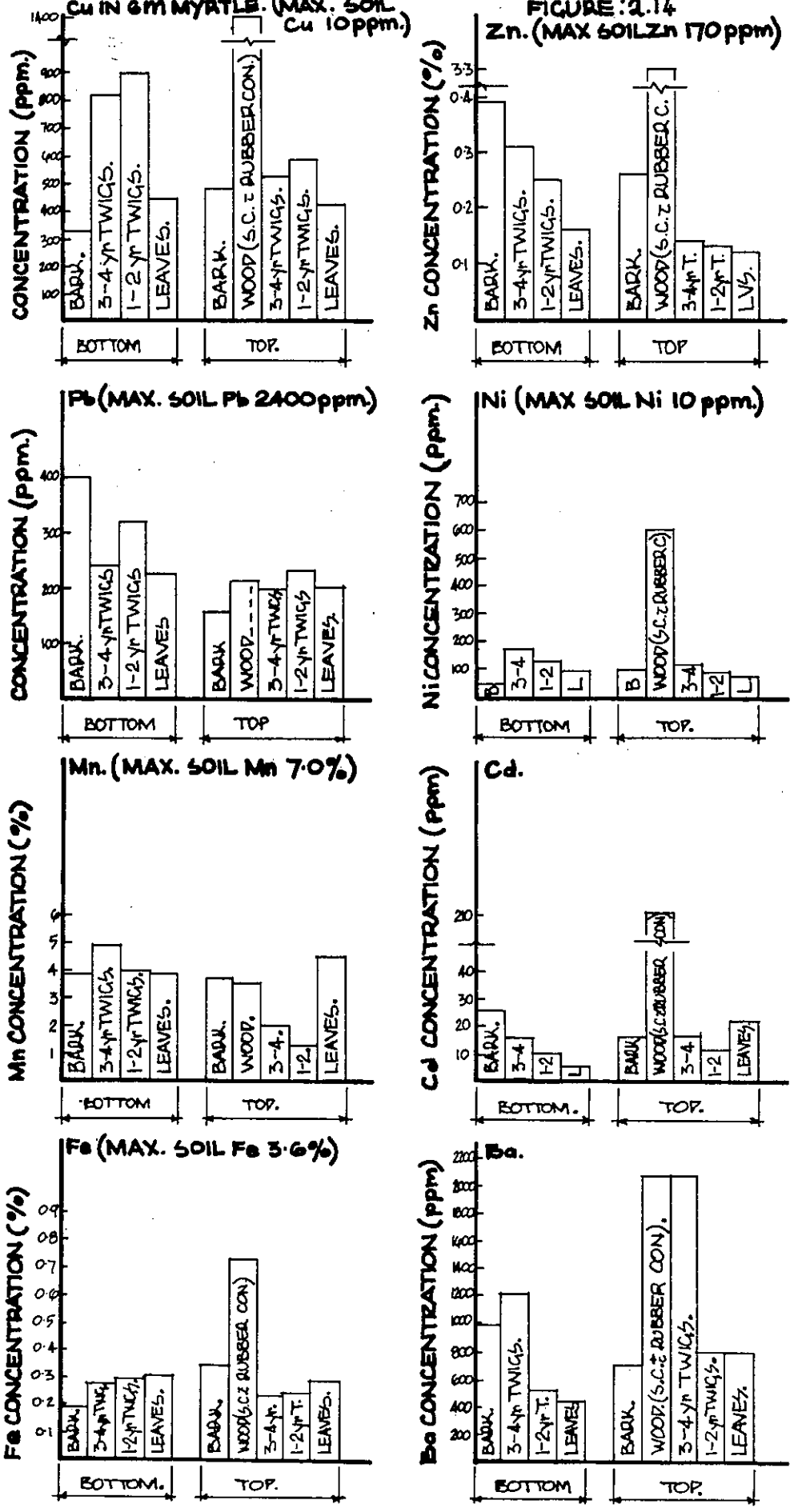
Lead is most effectively concentrated by the wood, young twigs and bark. The leaves usually contain the least lead. Generally lead appears in greater concentrations in the base of the plant. Off the anomaly, there is only a slight enrichment of lead in the plant ash, relative to the maximum soil value. On the anomaly, an exclusion mechanism in the plant operates to keep the lead in the plant ash below 400 ppm. The general increase in plant ash values with an increase in soil lead concentration suggests that, (even with the exclusion mechanism,) the plant is forced to increase its intake of lead when soil values rise drastically. The enrichment co-efficient varies from 0.1 (on the anomaly) to 1.1 (off the anomaly).

Zinc is most effectively concentrated by bark and twigs. The lowest values of zinc occur in the leaves. Greater amounts of zinc are concentrated in the older organs at the base of the plant. The enrichment co-efficient varies from 24 (on the anomaly) to 100 (off the anomaly).

Nickel is mainly concentrated in the older wood. The older twigs have slightly greater concentrations

ELEMENT DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ORGANS. TREE HEIGHT 6m. POSITION 400N 700W

FIGURE: 2.14



of nickel than do the bark, young twigs or leaves. The average enrichment co-efficient is 7 on the anomaly and 12 off the anomaly.

Manganese is most effectively concentrated in the bark with the other organs generally concentrating the element by similar amounts. Little difference exists in the concentration of manganese between the base or apex. The enrichment co-efficient varies from 0.2 to 0.7 on the anomaly and from 7 to 12 off the anomaly.

Iron's behaviour is similar to that of nickel in that it is mainly concentrated in the older wood. In general it appears to be more strongly concentrated in the older organs. The enrichment co-efficient is 0.1 both on and off the anomaly.

Cadmium is mainly concentrated in the wood and bark, with smaller amounts in the twigs and leaves. There is little difference in the concentration of cadmium in older or younger organs.

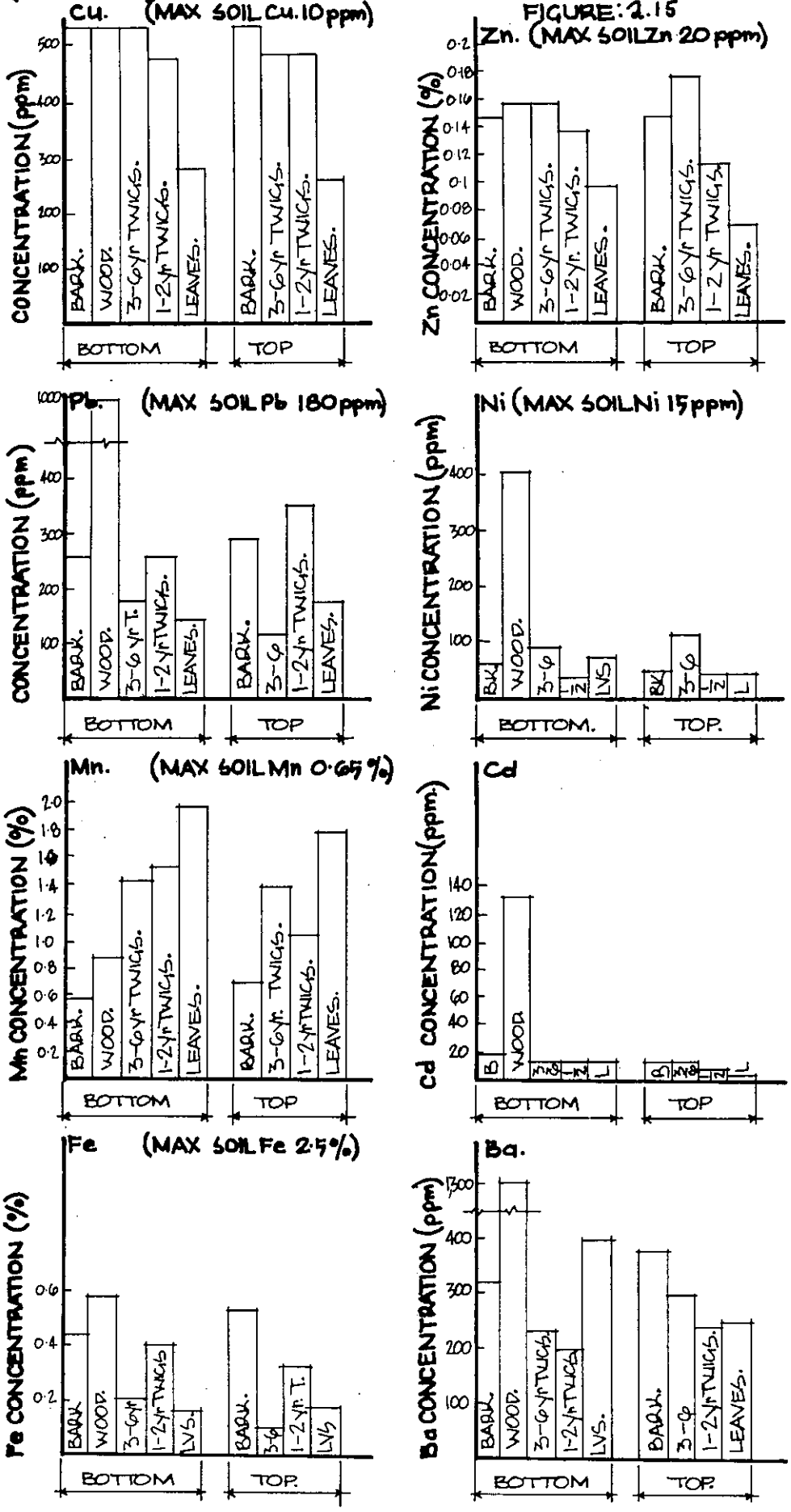
Barium is generally more concentrated in the older twigs than in any other organ. Its lowest concentration is in the leaves of the plant. There is more barium in the organs at the apex than in those at the base.

(b) Element Distribution in Leptospermum nitidum Organs (Figure 2.15).

Copper is effectively concentrated by bark, wood and twigs, with smaller concentrations in the leaves. There is little difference between 'bottom' and 'top' concentrations, suggesting that copper is

ELEMENT DISTRIBUTION IN LEPTOSPERMUM NITIDUM (TEA TREE) ORGANS. TREE HEIGHT 3·5m. POSITION 400N 480W

FIGURE: 2.15



an essential biogenic element. The enrichment co-efficient ranges from 30 to 52. These high values support the suggestion that it is an essential element.

Lead is most effectively concentrated in the wood and this is followed by the concentration in young twigs and bark. Old twigs and leaves have the lowest concentration of lead. In general there is little difference in lead in the apex or base of the tree. The enrichment co-efficient ranges from 0.8 to 2.

Zinc is uniformly concentrated in the bark, wood and twigs with lower concentrations in the leaves. Slightly lower values are evident in the organs of the apex. The enrichment coefficient ranges from 40 to 90. Once again these high values suggest that zinc is an essential biogenic element.

Nickel is selectively concentrated in wood and then uniformly concentrated in the other organs. Little difference exists between the nickel content of organs in the apex and base of the plant. The enrichment coefficient is approximately 7.

Manganese is most efficiently concentrated in the leaves. This is followed by twigs, wood and bark. The organs in the upper sections of the tree contain less manganese than their counterparts in the base. The enrichment coefficient ranges from 1.0 to 3.

Iron is most effectively concentrated in the wood and then the bark. The young twigs are next, with the older twigs and leaves containing the least iron.

There is some decrease in iron from the base to the apex but it is hardly significant. The enrichment coefficient ranges from 0.8 to 0.2.

Cadmium is selectively concentrated in the wood with very little occuring in other organs.

Barium is effectively concentrated in the wood, bark, and leaves of the species. No enrichment coefficient could be calculated for barium and cadmium as the concentrations of these elements in the soils were unknown.

(c) Element distribution in Anodopetalum biglandulosum Organs (Figure 2.16).

Copper is most effectively concentrated in the wood and older twigs, with the leaves containing the least copper. In general there are higher concentrations of copper in the organs at the base of the tree. The enrichment coefficient varies from 325 to 20.

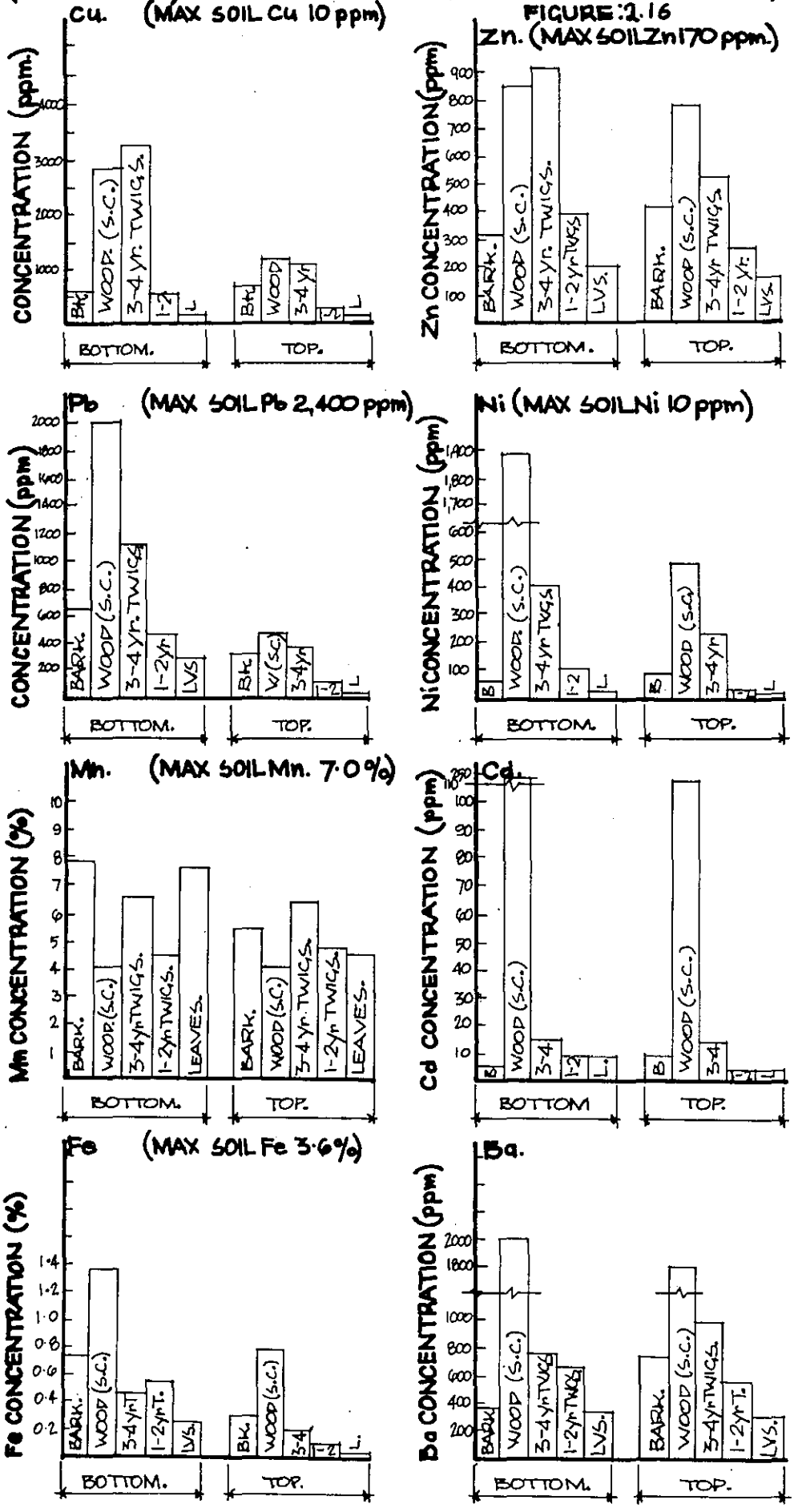
Lead is most efficiently concentrated in the wood and then the older twigs. Leaves contain the least lead. There is more lead in the organs at the base than in those at the apex. The enrichment coefficient varies from 0.02 to 0.8.

Zinc is most obviously concentrated in the wood and older twigs, with the least zinc in the leaves. In general the basal organs are enriched in zinc with respect to those in the apex. The enrichment coefficient varies from 1.2 to 5.5

Nickel is mainly concentrated in the wood. The next highest concentration of nickel occurs in the older twigs, while the lowest concentration occurs in the leaves. Nickel is present in higher concentrations

ELEMENT DISTRIBUTION IN ANODOPETALUM BIGLANDULOSUM. (HORIZONTAL) ORGANS. TREE HEIGHT. 6 m. POSITION 400N 700W.

FIGURE: 2.16



in the base of the plant. The coefficient varies from 5 to 190.

Manganese is strongly concentrated in the bark, leaves and twigs with the least in the wood. In general there is a slight increase in manganese in the organs at the base of the tree. The enrichment coefficient varies from 0.6 to 1.7.

Iron is most efficiently concentrated in the wood and then the bark. The lowest concentration of iron occurs in the leaves. The basal organs have a higher concentration of iron than those at the apex. The enrichment coefficient ranges from 0.06 to 0.39.

Cadmium is selectively concentrated in the wood and least concentrated in the leaves. There is little difference between the cadmium in the apex and base of the tree.

Barium is strongly concentrated in the wood and less strongly in the twigs and bark. The leaves contain the least amount of the element. There is little difference between the elemental concentration in the base and apex of the plant.

(iii) Summary.

(a) Nothofagus cunninghamii:

This species most effectively concentrates Cu, Pb, Cd, Ni and Fe in the wood, Mn, Pb and Zn in the bark and Ba in the twigs. The leaves contain the lowest concentrations of Cu, Pb, Zn, Ni, Ba and Cd. The organs at the base of the plant are more effective in concentrating Cu, Pb, Zn and Fe than their counter-

parts at the apex. Cadmium occurs in greater concentrations at the apex.

An evaluation of the enrichment coefficient on and off the anomaly gives an indication of the likely usefulness of the species for reflecting that element when growing on a geochemical soil anomaly. Nothofagus cunninghamii has the following approximate enrichment coefficients:

Element	Cu	Pb	Zn	Ni	Mn	Fe
On Anomaly	50-80	0.1	24	7	0.2-0.7	0.1
Off Anomaly	50-80	1.1	100	12	7-12	0.1

Zinc and copper have high enrichment coefficients, which only increase the background level in the plant ash. This may render an anomaly more difficult to detect. These high coefficients probably suggest that these two are essential elements.

Lead, nickel and manganese have lower coefficients on the anomaly than off the anomaly. This indicates that the enrichment of the element in the plant does not keep pace with the increased soil concentration. That is, some form of chemical or botanical exclusion mechanism comes into operation above a certain soil-element concentration. However, as there is a real increase in plant-element concentration with an increase in soil-element concentration, these elements could be used in Nothofagus cunninghamii for reflecting soil-element values.

The constant enrichment coefficient of iron suggests that no exclusion mechanism exists and that

iron is not antagonistic towards any other element present in high concentrations in the soil. This freedom from interference suggests that iron in Nothofagus cunninghamii would be effective in reflecting the concentrations of iron in soils.

The table of enrichment coefficients for lead in Nothofagus cunninghamii (Figure 2.17a) supports the conclusions drawn above. The enrichment coefficients for all organs decrease towards the soil anomaly and increase away from it. As the coefficients remain small, lead would be a useful indicator in biogeochemical work with this species.

(b) Leptospermum nitidum.

This species most effectively concentrates Cu, Pb, Zn, Ni, Fe, Ba, and Cd in the wood, Cu in the bark, Zn in the twigs and Mn in the leaves. The leaves contain the lowest concentration of Cu, Pb, Zn, Ni and Fe with the bark containing the lowest concentration of Mn. The organs at the base of the plant are most efficient in concentrating Zn, Mn and Fe.

The enrichment coefficients for Leptospermum nitidum are listed below:-

Element	Cu	Pb	Zn	Ni	Mn	Fe
Range,	30-52		40-90		1-3	
(Off anomaly).		0.8 - 2		7		0.8-0.2

PLANT/SOIL RATIO FOR LEAD IN NOTHOFAGUS (ASH)
(Relative accumulation for Lead - 400N)

Easting:	Soil Pb ppm	Wood/ Soil	Bark/ Soil	Twig/ Soil	Leaf/ Soil	Average Plant/ Soil Ratio
200E	270	-	-	-	-	
00W	190	1.03	2.32	4.21	1.16	1.50
200W	200	-	-	-	-	
300W	180	-	1.50	1.78	1.08	1.18
400W	130	0.77	0.92	2.77	0.88	1.34
500W	180	0.55	1.50	2.22	1.06	
600W	160	0.88	1.09	2.81	0.81	1.27
700W	2400	0.11	0.18	0.09	0.20	0.11
800W	310	1.16	(2.00) (2.26)	0.84	1.29	1.51
900W	450	1.02	1.09	0.93	0.64	0.92
1000W	100	-	2.00	2.30	2.70	2.33
1100W	50	6.6	2.50	3.20	3.30	3.90
1200W	60	2.79	2.50	4.67	5.17	3.75
1300W	70	-	-	(2.71) (3.29)	3.14	3.05
500W Bottom ↕	180	1.17	0.89	(0.92) (1.89)	0.90	
Top ↕		0.36	1.67	(1.00) (1.03)	0.61	
700W Bottom ↕	2400		0.17	(0.10) (0.13)	0.10	
Top ↕		0.09	0.06	(0.08) (0.10)	0.08	

Figure: 2.17a

ELEMENTAL RATIOS FOR NOTHOFAGUS (ASH) - 400N

Organ:	Easting:	$Fe/_{Ni}$	$Mn/_{Ni}$	$Fe/_{Cu}$	$Mn/_{Cu}$	$Pb/_{Cu}$
Wood	Ridge	15.86	393	4.42	110	0.56
	00W	11.43	300	4.80	126	0.39
	400W	11.82	473	4.64	186	0.36
	500W	16.92	554	5.24	171	0.48
	600W	17.14	971	4.29	243	0.50
	700W	13.94	194	7.19	100	0.84
	800W	100.00	480	8.93	43	0.64
	900W	17.39	78	5.88	26	0.68
	1100W	13.68	97	7.22	51	0.46
	1200W	8.39	97	6.84	79	0.51
Bark	Ridge	69.09	1891	13.10	359	2.69
	00W	58.46	969	8.44	140	0.98
	300W	61.82	1255	6.54	133	0.52
	400W	40.00	1886	7.00	330	0.60
	500W	65.71	1686	4.26	109	0.50
	600W	47.50	1275	6.33	170	0.58
	700W	213.33	1022	14.12	68	0.65
	800W	23.16	211	11.28	103	1.79
	900W	60.00	271	11.59	52	1.11
	1000W	10.34	15.9	4.84	7.4	0.65
	1100W	29.23	446	7.60	116	0.50
	1200W	9.52	190	5.88	118	0.88

Figure 2.17

ELEMENTAL RATIOS FOR NOTHOFAGUS (ASH) - 400N.

Organ:	Easting:	$Fe/_{Ni}$	$Mn/_{Ni}$	$Fe/_{Cu}$	$Mn/_{Cu}$	$Pb/_{Cu}$
Twigs	Ridge	147.5	1475	18.44	184	4.38
	00W	50.53	716	10.43	148	1.74
	300W	42.67	867	5.52	112	0.55
	400W	56.36	1164	7.75	160	0.90
	500W	95.38	10.92	10.33	118	0.67
	600W	41.54	1292	7.11	221	1.18
	700W	23.20	416	5.00	90	0.38
	800W	45.00	700	4.19	65	0.60
	900W	24.80	232	4.43	41	0.60
	1000W	12.67	207	4.13	67	0.50
	1100W	10.37	230	4.24	94	0.48
	1200W	8.97	43	3.71	18	0.40
	1300W	11.05	389	3.82	135	0.35
	1300W	20.95	495	4.23	100	0.44
Leaves	Ridge	40.00	617	8.28	128	3.03
	00W	40.00	1289	8.18	264	1.00
	300W	62.50	2150	8.06	277	0.63
	400W	22.67	1147	9.71	491	0.66
	500W	35.56	1200	5.93	200	0.70
	600W	40.00	1943	4.67	227	0.43
	700W	108.00	1020	7.71	73	0.70
	800W	6444	733	5.80	66	0.80
	900W	2000	229	4.38	50	0.60
	1000W	17.14	238	4.19	58	0.63
	1100W	23.08	554	3.26	78	0.36
	1200W	17.33	293	473	80	0.56
	1300W	17.93	517	6.34	183	0.54

Figure: 2.18

The high values for copper and zinc suggest that these are essential, biogenic elements and hence are of little biogeochemical use. The low enrichment co-efficients of lead, nickel and manganese and iron indicate that these elements could be useful in reflecting soil-element concentrations.

(c) Anodopetalum biglandulosum.

This species most effectively concentrates Cu, Pb, Zn, Ni, Fe, Cd and Ba in the wood and Mn in the leaves and bark. The leaves contain the least Cu, Pb, Zn, Fe, Ba and Cd, while the wood contains the least Mn. The organs at the base of the tree contain more Cu, Pb, Zn, Ni and Mn than their counterparts at the apex.

The enrichment coefficients for Anodopetalum biglandulosum are listed below:-

Element	Cu	Pb	Zn	Ni	Mn	Fe
Range,	20-325		1.2-5.3		0.6-1.1	
(On Anomaly),		0.02-0.8		5-190		0.06-0.39

The large variation inthe value of the ratio for copper and nickel preclude these elements from any biogeochemical use with this species. Lead, manganese, iron and possibly zinc could be useful in reflecting soil-element values.

(iv) Conclusions.

In general, the most efficient organ for

concentrating elements was the wood. This followed by the bark, twigs and finally the leaves. Manganese was the main exception to this generalization, with it being most strongly concentrated in the leaves. However, the organs with the highest concentration of elements will tend to have the highest background value and hence be the least sensitive in the detection of any anomaly. So, in effect, the most sensitive organs that could be used in general biogeochemical work, are the leaves and the young twigs of the three species.

The large and variable enrichment coefficients of copper, zinc and nickel indicate that these elements would be unsuitable for biogeochemical work. Lead, manganese and iron have small enrichment coefficients and hence these elements have promise in biogeochemical work. The enrichment coefficients suggest that copper and zinc are essential elements to the species. The other elements are biogenic and probably ballast elements.

The organs at the base of the plant were more effective in concentrating the various elements than their counterparts at the apex. This can be explained by either one or both of two reasons. Either the lower organs are older and hence have accumulated a greater concentration of the elements, or the elemental concentrations in the tissues may well be a function of the translocation distance from the root-tips, to the respective organs. Hence the organs around the base would contain the highest concentrations of

elements. As such they would have the highest background values, and would be the least sensitive organs to use in a biogeochemical survey.

This orientation survey has shown that the most sensitive organs for biogeochemical work would be the young twigs and leaves of the species. Also, greater sensitivity can be gained by sampling species as high up the tree as possible.

2.6 DETAILED PILOT SURVEY.

(i) Outline of Method.

Having determined that leaves and twigs were the most sensitive in reflecting a soil anomaly, this was tested by a full scale, detailed pilot survey. This survey was conducted down 400N from 800E to 1300W. Samples of the bark, wood, twigs and leaves were taken of the three previously selected species at 100 foot intervals across the anomaly.

The following three results were possible from this survey. The organs would not reflect the soil-element values, they would reflect the soil-lead values, or they would reflect the soil values only for the specific element used.

In order to determine which of the above results occur, the distribution of the elements of interest down 400N, are listed below (From Figure 3.44).

High soil-lead values occur at 200W and between 600W and 1000W, with peak values at 700W.
The rise in soil values for all elements to the east of 00W is caused by down-slope contamination from the Hercules Mine.

Manganese soil values are high between 500W and 1300W, with peak values at 1125 W.

Copper concentration in the soils is low, with minor enrichment between 700W and 900W. Highest values occur at 700W.

Zinc values in the soils are high between 700W and 1300W with peak values between 700W and 900W.

Nickel is present in low concentrations with minor enrichment between 900W and 1300W. Highest values occur at 1125W.

Iron concentration in the soils is high between 700W and 1300W, with peak values at 1125 W.

Manganese soil values are high between 500W and 1300W with peak values at 1125W.

In summary, copper, lead and zinc have the same distribution. Further down the line, iron, manganese and nickel have a similar distribution.(Figure 3.44)

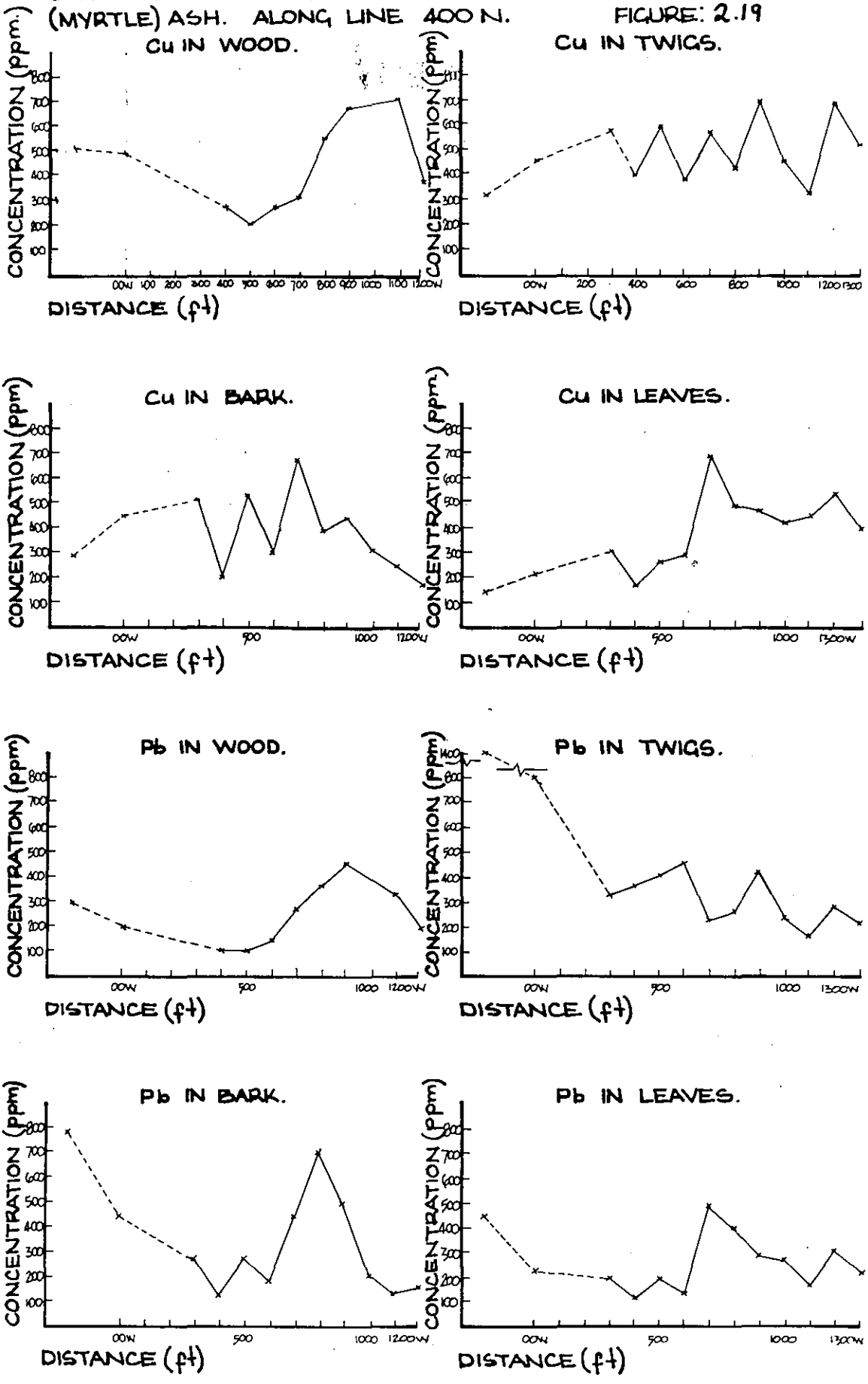
(ii) Primary Results (Figures 2.19 to 2.27).

The analytical data (Appendix D.1) were plotted down the line 400N (horizontal axis), with the concentration of the element in plant ash along the vertical axis. Graphs were drawn for the elements Cu, Pb, Zn, Ni, Mn, Fe, Cd and Ba for each of the organs wood, bark, twigs and leaves. These were drawn for Nothofagus cunninghamii (Figures 2.19 to 2.27). Leptospermum nitidum (Figures 2.23to 2.25) and Anodopetalum biglandulosum (Figures 2.26 to 2.27).

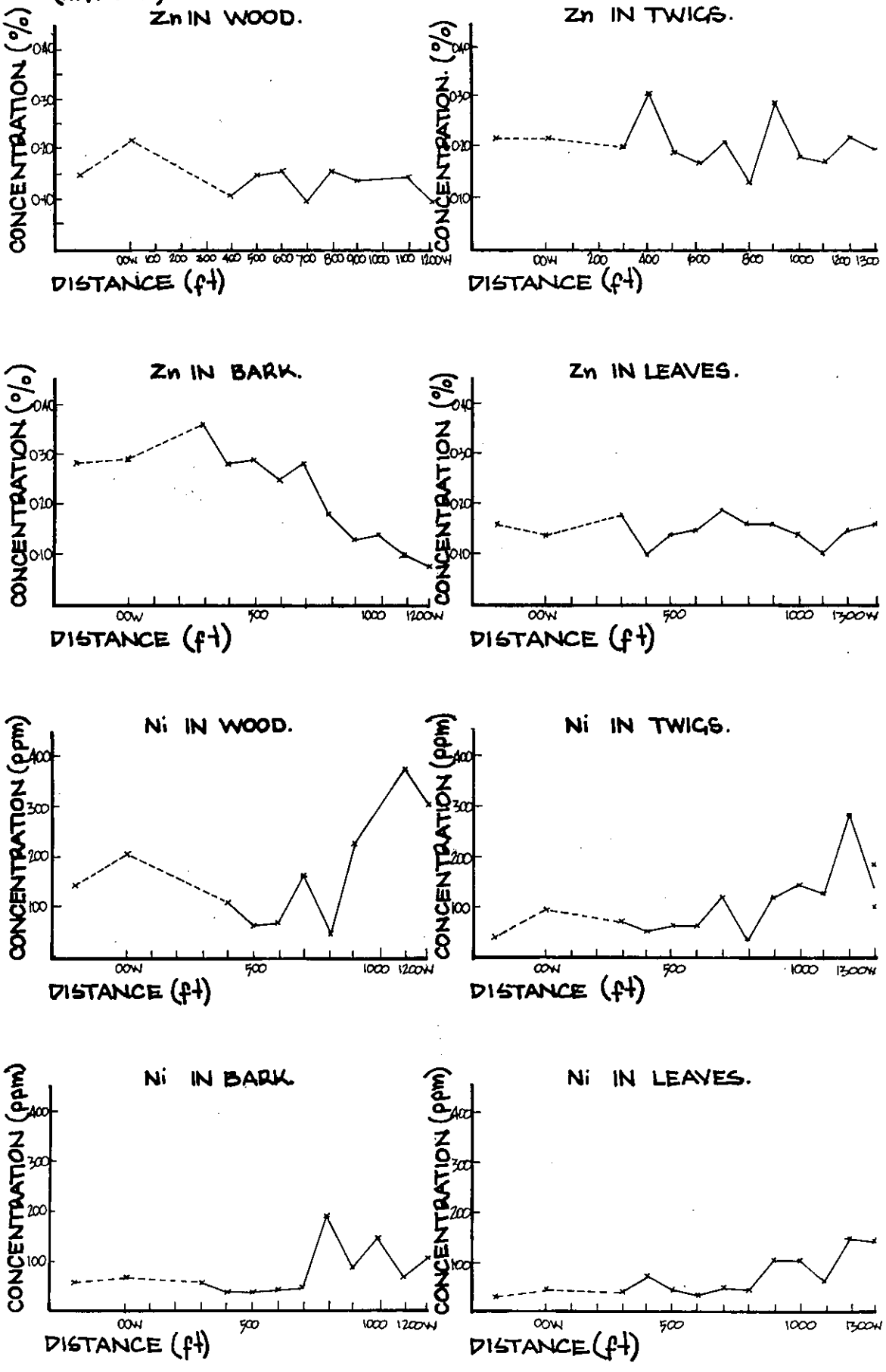
(a) Reflection of Soil-Element Concentrations by Nothofagus cunninghamii (Figures 2.19 to 2.22)

Copper values in leaves accurately reflect the soil concentration of lead and copper. However the peak of the copper values in wood is displaced down slope of the main anomaly. A glance at the parent rock values for copper down 400N (Figure 2.30)suggests that this delayed 'copper peak' in the wood reflects

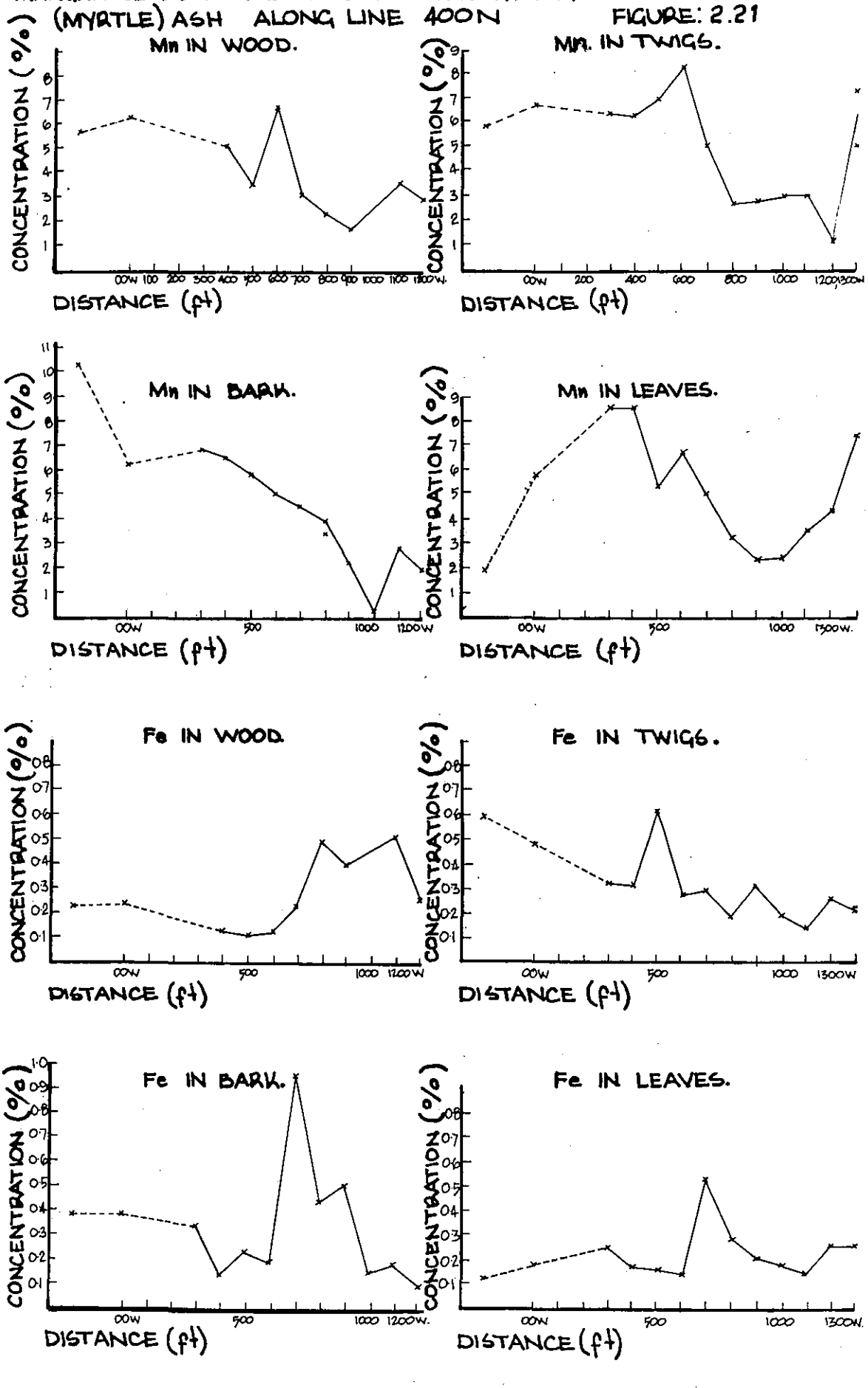
COPPER AND LEAD DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ASH. ALONG LINE 400 N. FIGURE: 2.19



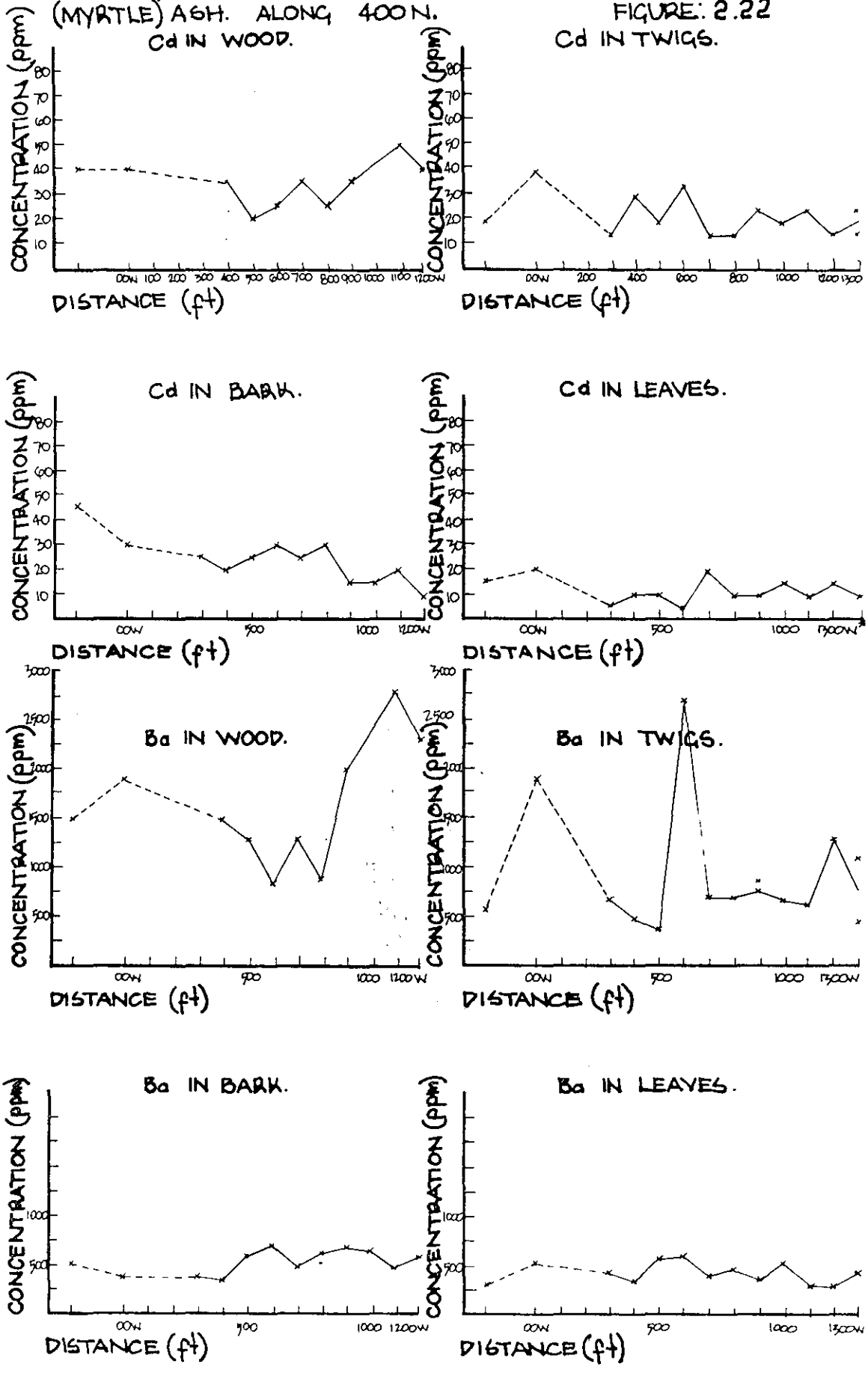
ZINC AND NICKEL DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ASH. ALONG LINE 400 N. FIGURE: 2.20



MANGANESE AND IRON DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ASH ALONG LINE 400N FIGURE: 2.21



CADMIUM & BARIUM DISTRIBUTION IN NOTHOFAGUS CUNNINGHAMII (MYRTLE) ASH. ALONG 400 N. FIGURE: 2.22



the copper values in the parent rock. This could also explain the extra peak at 1200W in the leaf-copper.

Lead values in wood, bark and leaves accurately reflect lead concentration in the soils. The up-slope contamination to the east of 00W is also reflected by the plants. Even the minor anomaly at 500W is reflected by the bark and leaves.

Zinc values in all organs are too erratic to be useful and do not reflect element concentration in soils or parent rock.

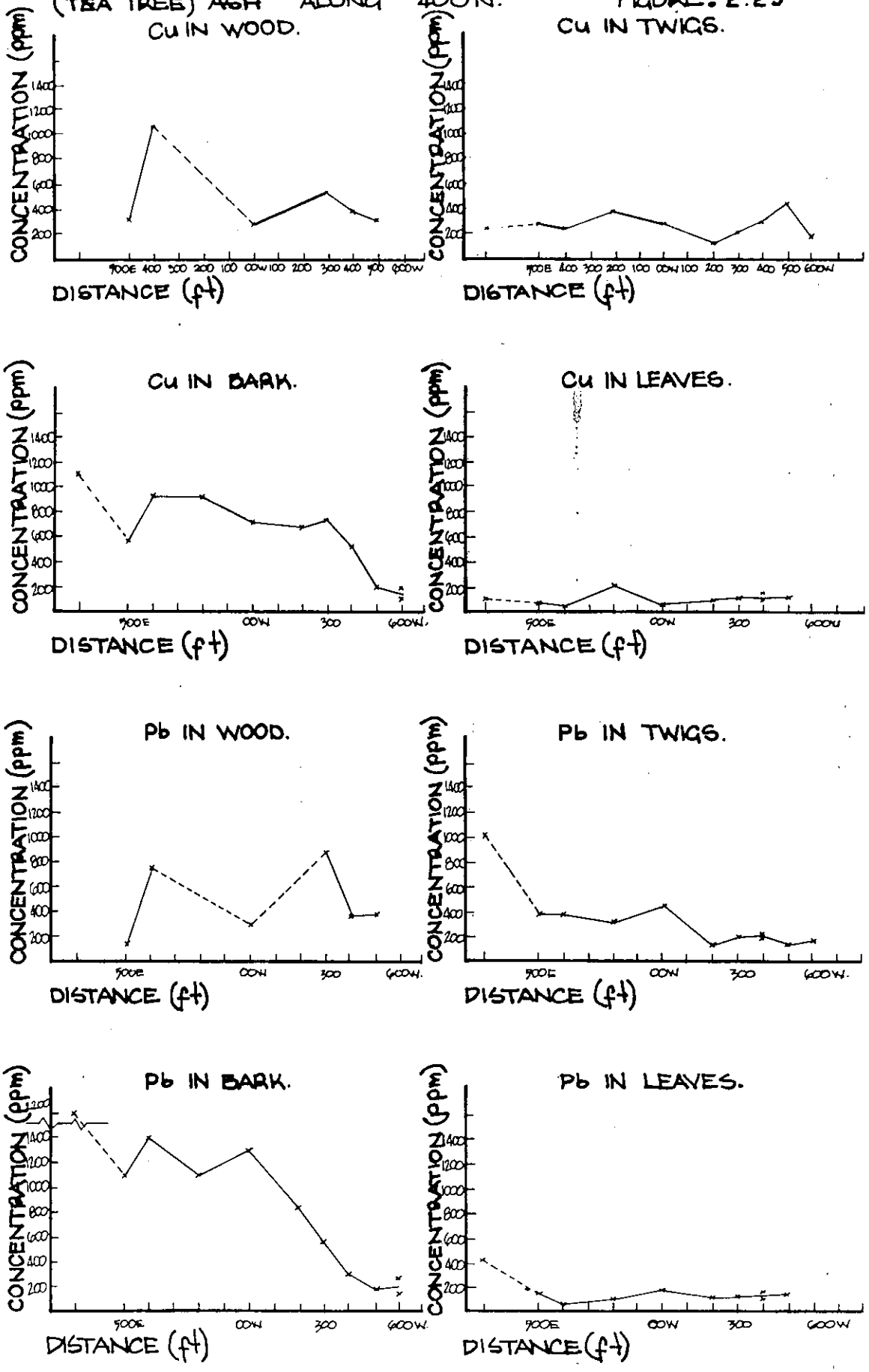
Nickel values in wood and twigs could be interpreted as an indistinct reflection of lead soil concentration, but they are more likely a reflection of nickel values in the soil and parent rock (Figure 2.30).

Manganese in plant ash does not reflect element values in soils or rocks. In fact the plant-manganese follows a distinct inverse relationship to the lead concentration in the soil.

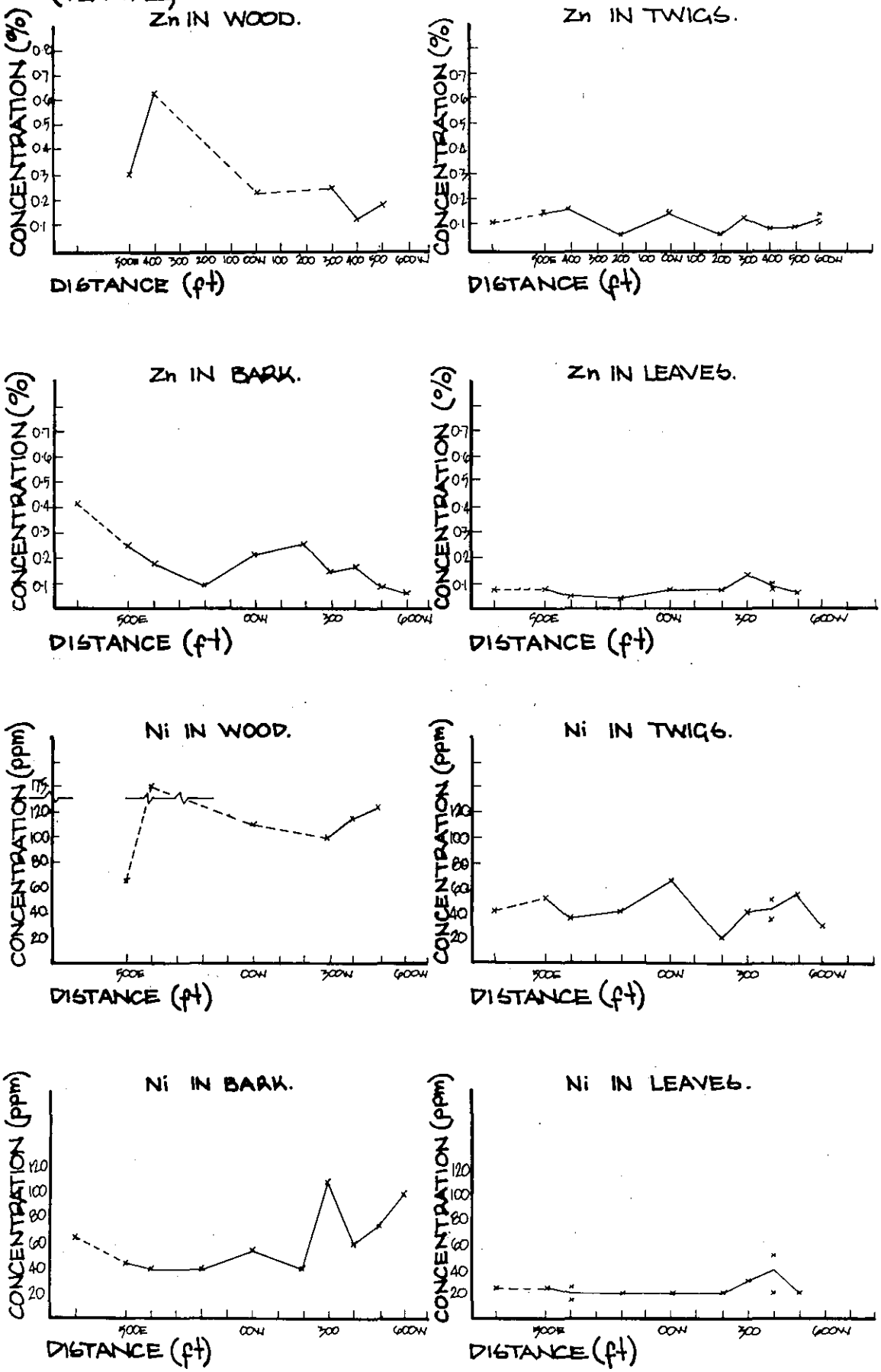
Iron concentrations in wood, bark and leaves accurately reflect the lead concentrations in the soil. Iron in the bark is exceptional in reflecting the lead-soil values. There is no tendency for the iron plant-ash concentrations to reflect the iron concentrations in the soils or parent rocks.

Cadmium and barium are too erratic to be useful and do not reflect lead concentration in soils. However it is interesting to note that the distribution of barium in wood (down 400N) is an exact replica of the distribution of nickel in wood down 400N.

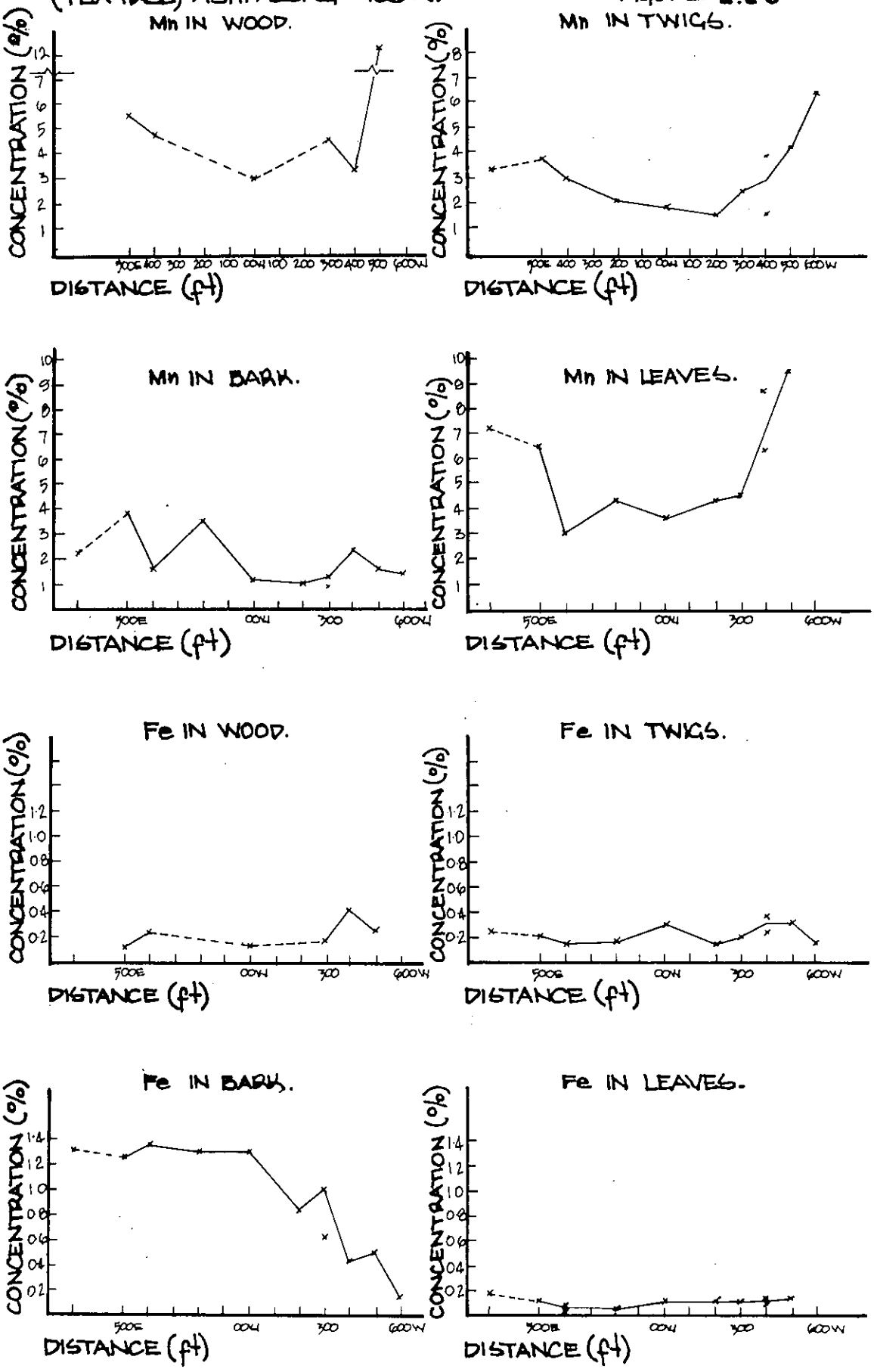
COPPER AND LEAD DISTRIBUTION IN LEPTOSPERMUM NITIDUM. (TEA TREE) A6H ALONG 400N. FIGURE: 2.23



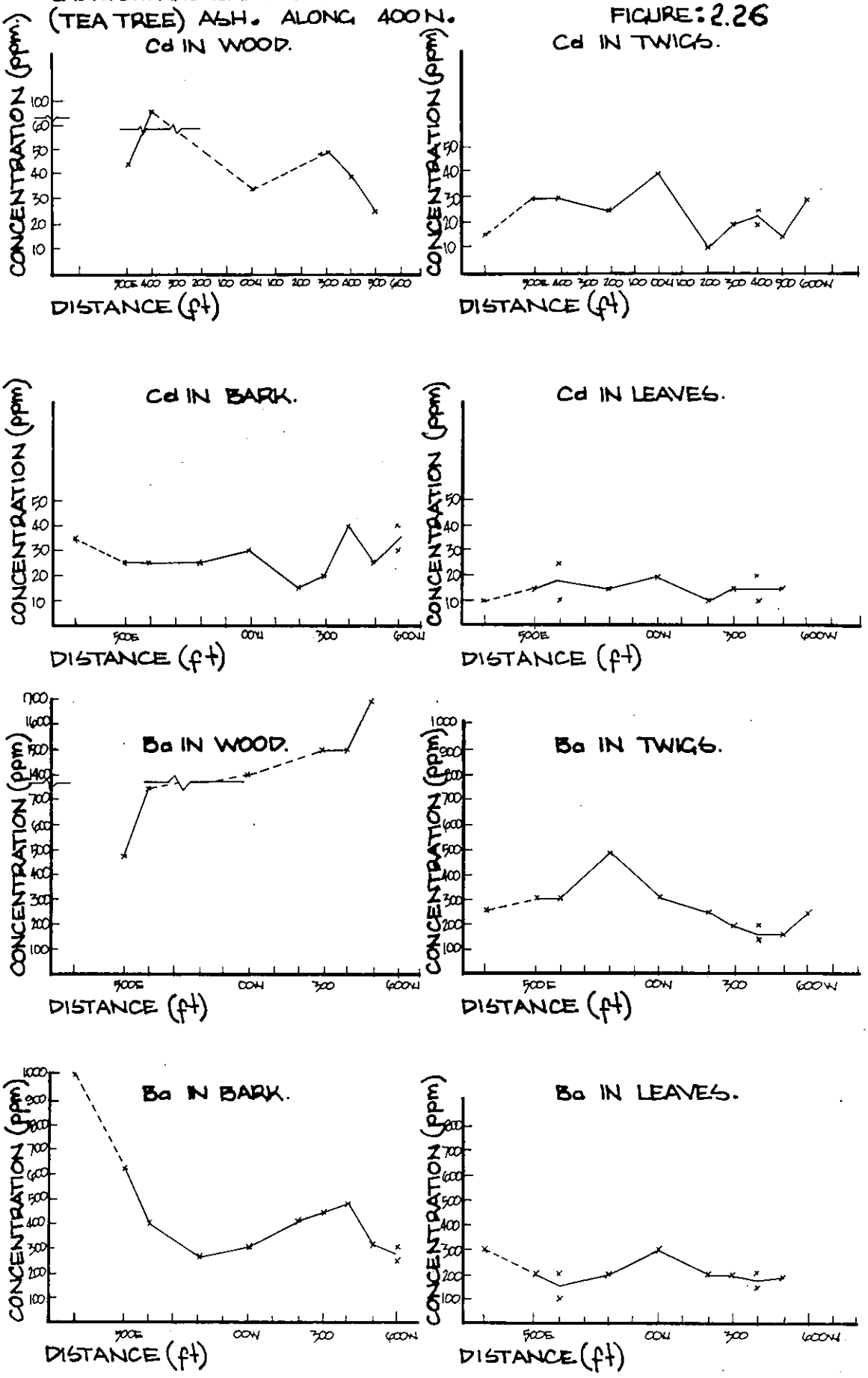
ZINC & NICKEL DISTRIBUTION IN LEPTOSPERMUM NITIDUM (TEA TREE) ASH. ALONG 400N. FIGURE: 2.24



MANGANESE & IRON DISTRIBUTION IN LEPTOSPERMUM NITIDUM (TEA TREE) A6H. ALONG 400 N. FIGURE: 2.25



CADMIUM AND BARIUM DISTRIBUTION IN LEPTOSPERMUM NITIDUM (TEA TREE) ASH. ALONG 400N. FIGURE: 2.26



This suggests a very close relationship or strong ratio between barium and nickel in the wood of Nothofagus cunninghamii.

(b) Reflection of Soil-Element Concentrations by Leptospermum nitidum (Figures 2.23 to 2.25).

Copper values in twigs do reflect the lead concentrations in soils down 400N, but the twigs are the only organ that does.

Lead, zinc, nickel and iron in this species do not reflect either the soil or parent rock concentrations of the elements.

Manganese concentration in wood, twigs and leaves reflect the soil concentrations of lead as do barium and cadmium in the twigs and bark.

(c) Reflection of Soil-Element Concentrations by Anodopetalum biglandulosum (Figures 2.26 to 2.27).

Copper values in the twigs accurately reflect the lead-soil concentrations.

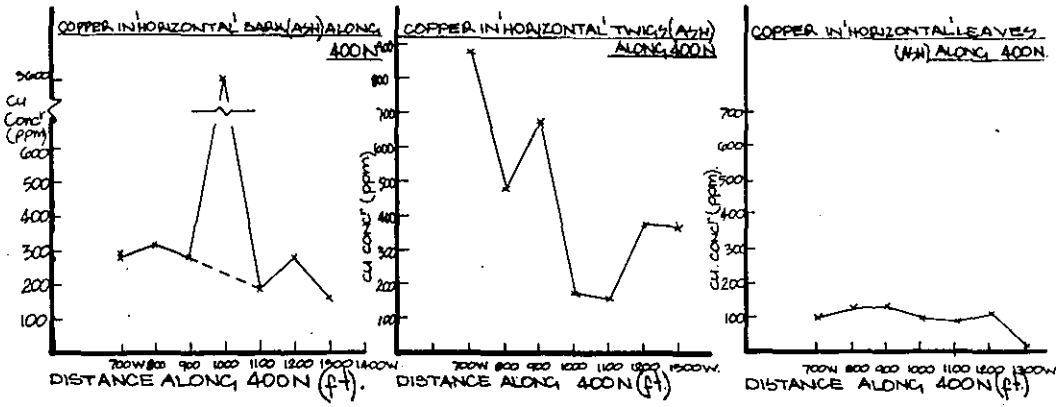
Lead and zinc values in plant ash do not reflect the soil anomaly.

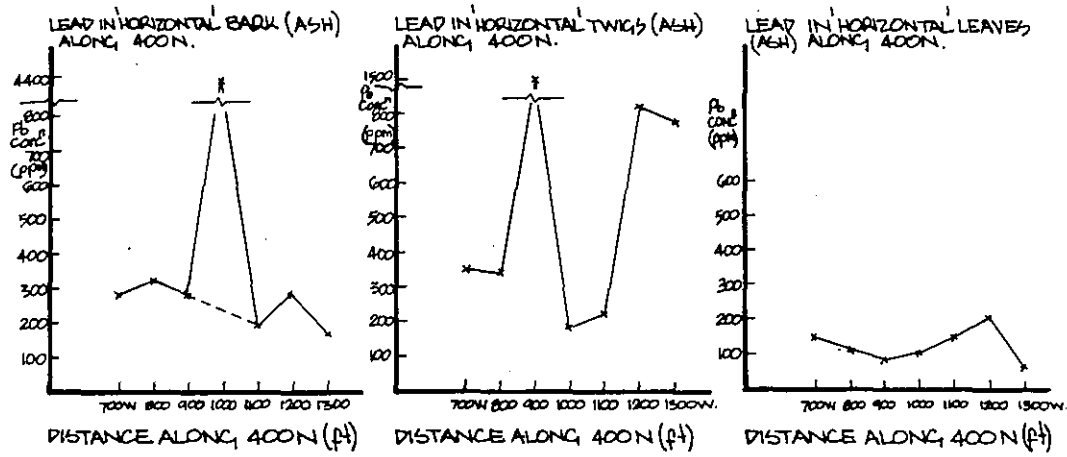
Nickel concentrations in the twigs do tend to reflect the lead values in the soils. It is of interest to note the influence of the nickel present in the parent rock, resulting in the rise at 1300W.

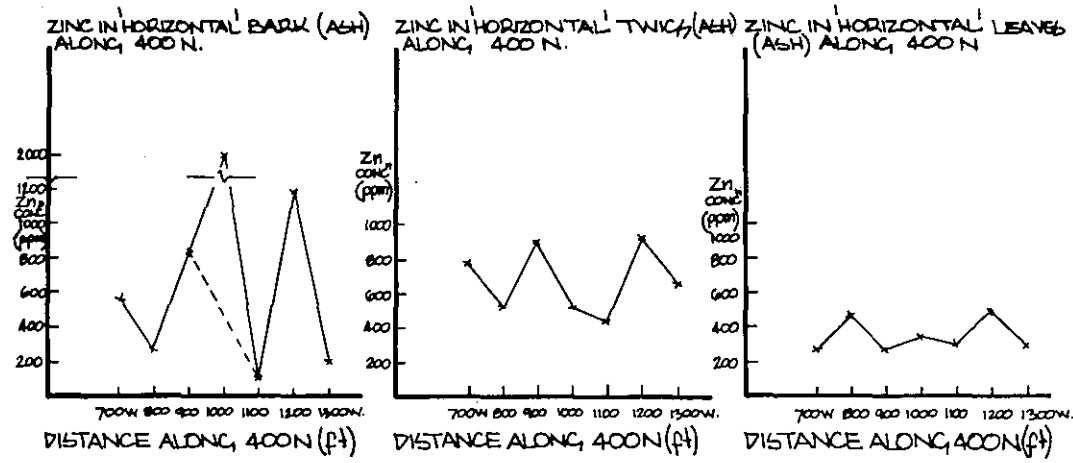
Manganese in bark possibly reflects the manganese in the parent rock while the manganese in the leaves reflects the lead-soil values.

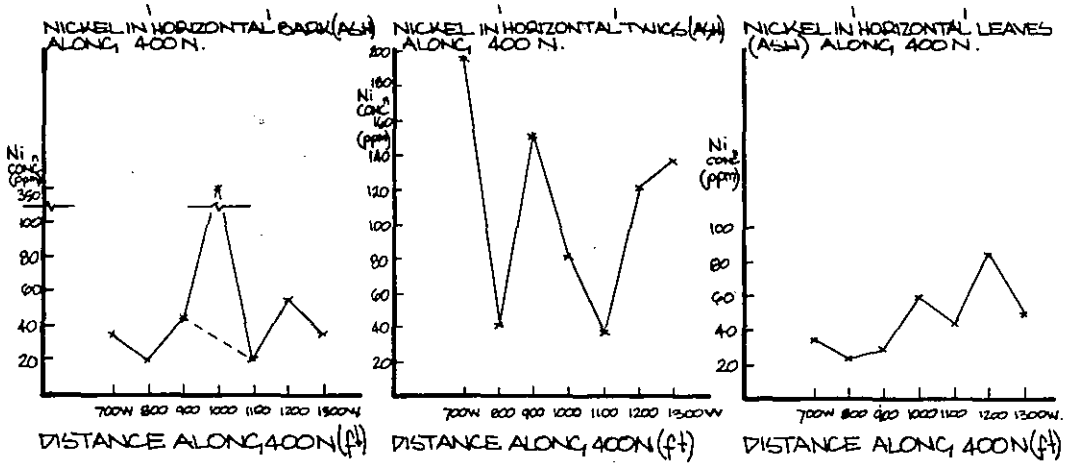
Iron concentration in the twigs of this species reflects the lead concentration in the soils while cadmium and barium do not.

COPPER, LEAD, ZINC & NICKEL DISTRIBUTION IN ANODOPETALUM BIGLANDULOSUM (HORIZONTAL) ASH, ALONG 400N FIGURE: 2.27

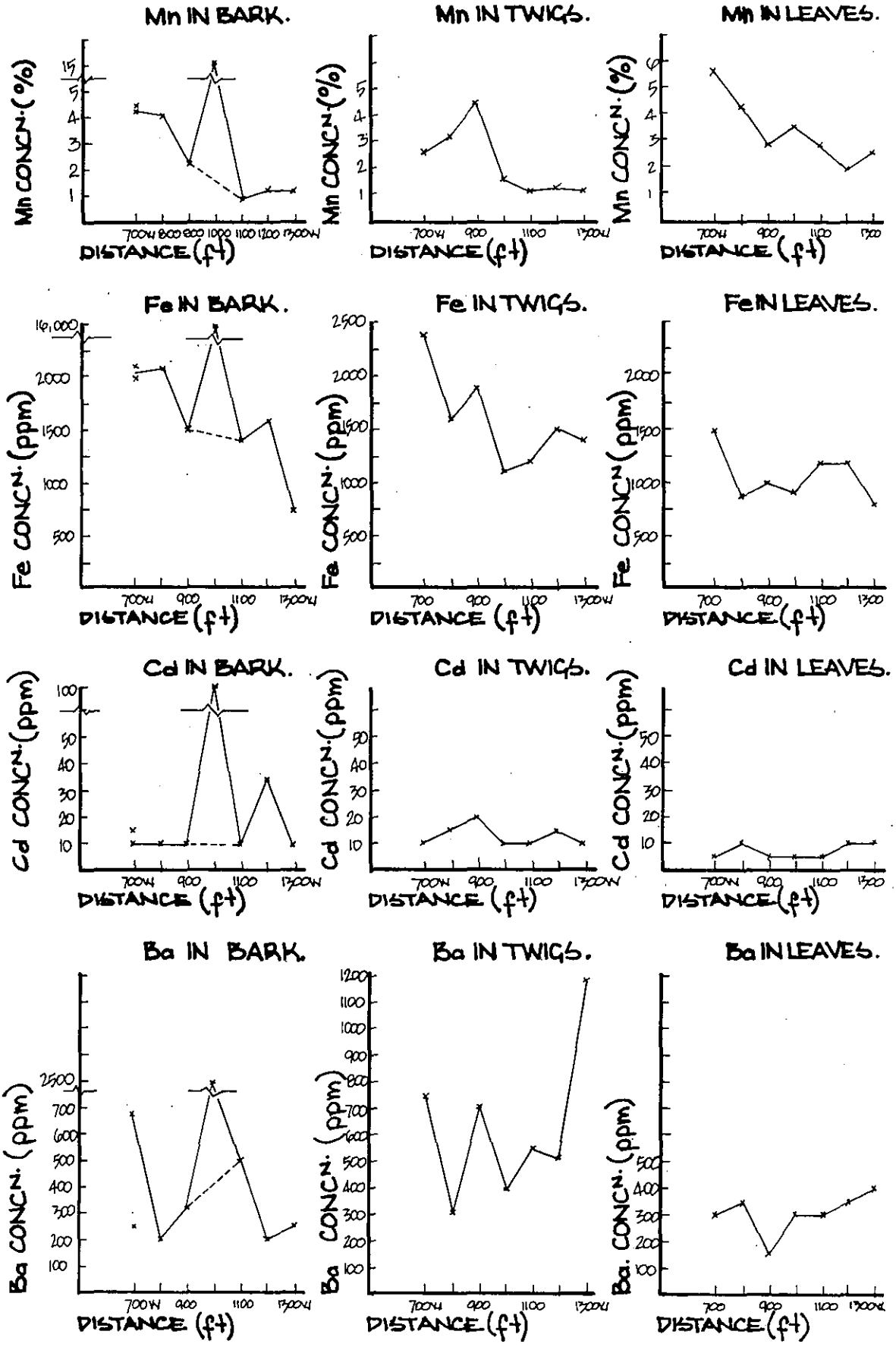








MANGANESE, IRON, CADMIUM AND BARIUM DISTRIBUTION IN ANODOPETALUM BIGLANDULOSUM (HORIZONTAL) ASH ALONG 400 N.
FIGURE : 2.28



PARENT ROCK SURVEY

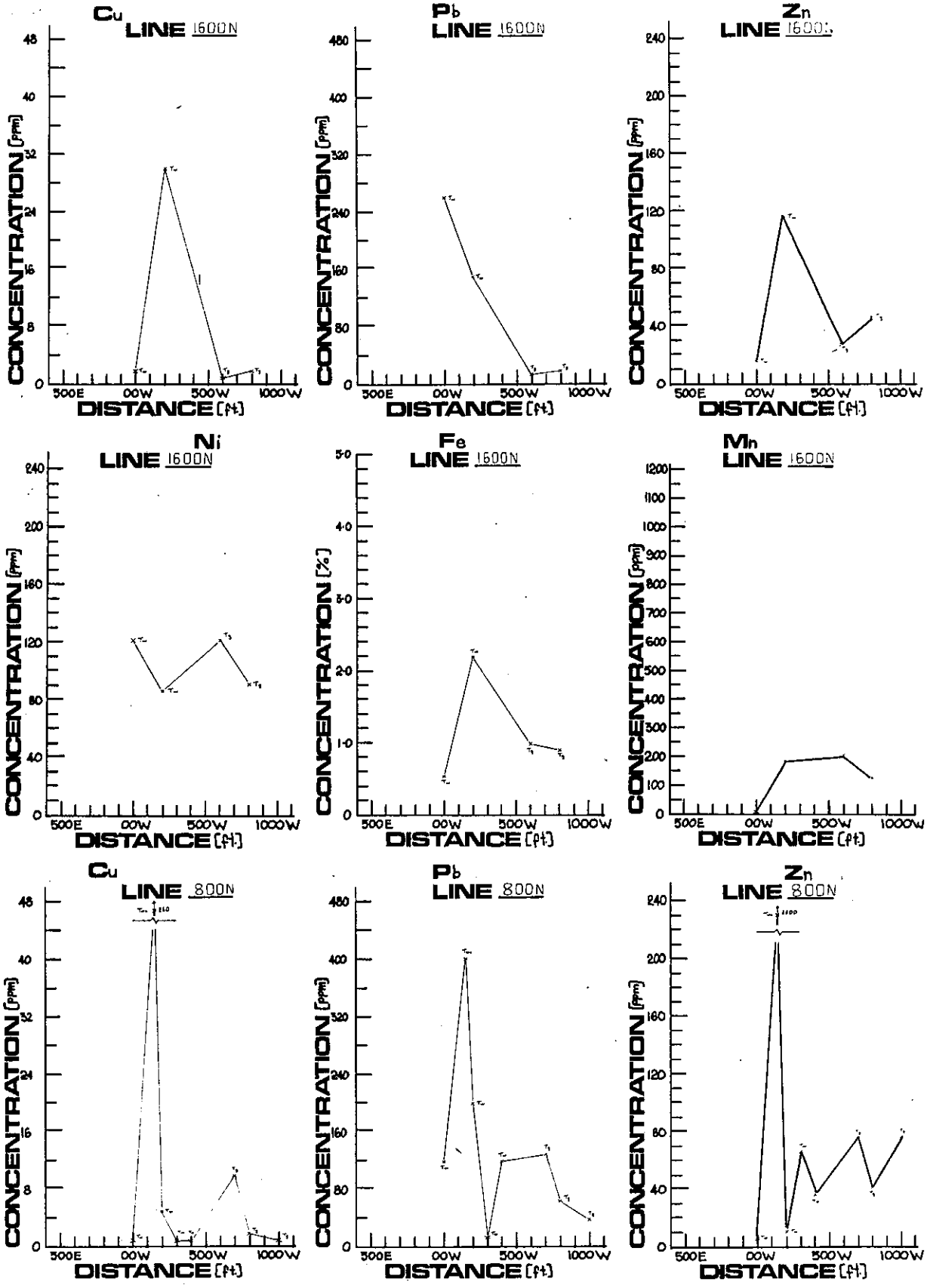


Figure: 2.29 Elemental Concentration along Cut Grid Line

Tw - White Siliceous Tuff

Tg - Green Sericite Tuff

S - Shale.

PARENT ROCK SURVEY

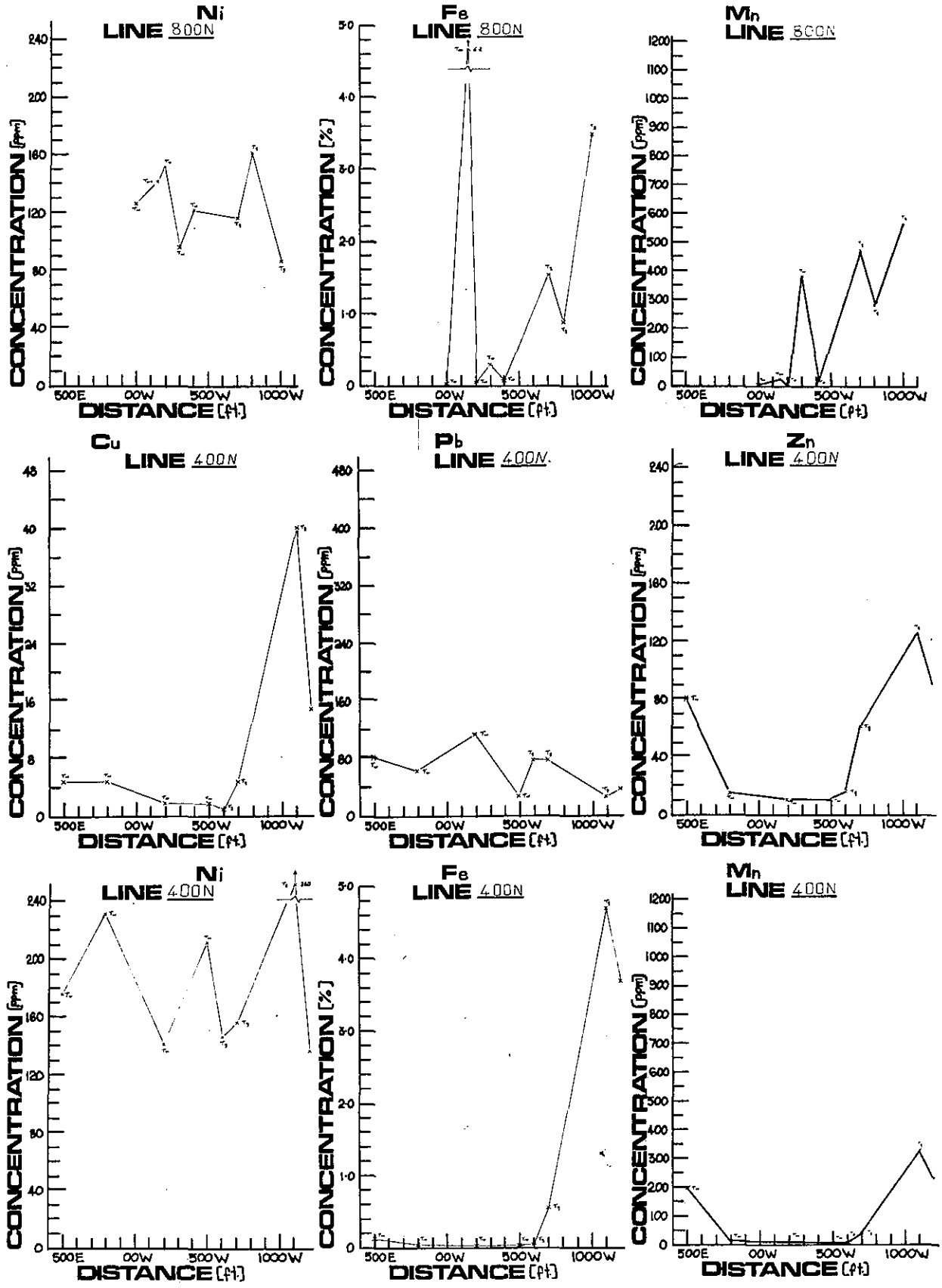


Figure: 2.30 Elemental Concentration along Cut Grid Line

Tw - White Siliceous Tuff

Tg - Green Sericite Tuff

S - Shale

PARENT ROCK SURVEY

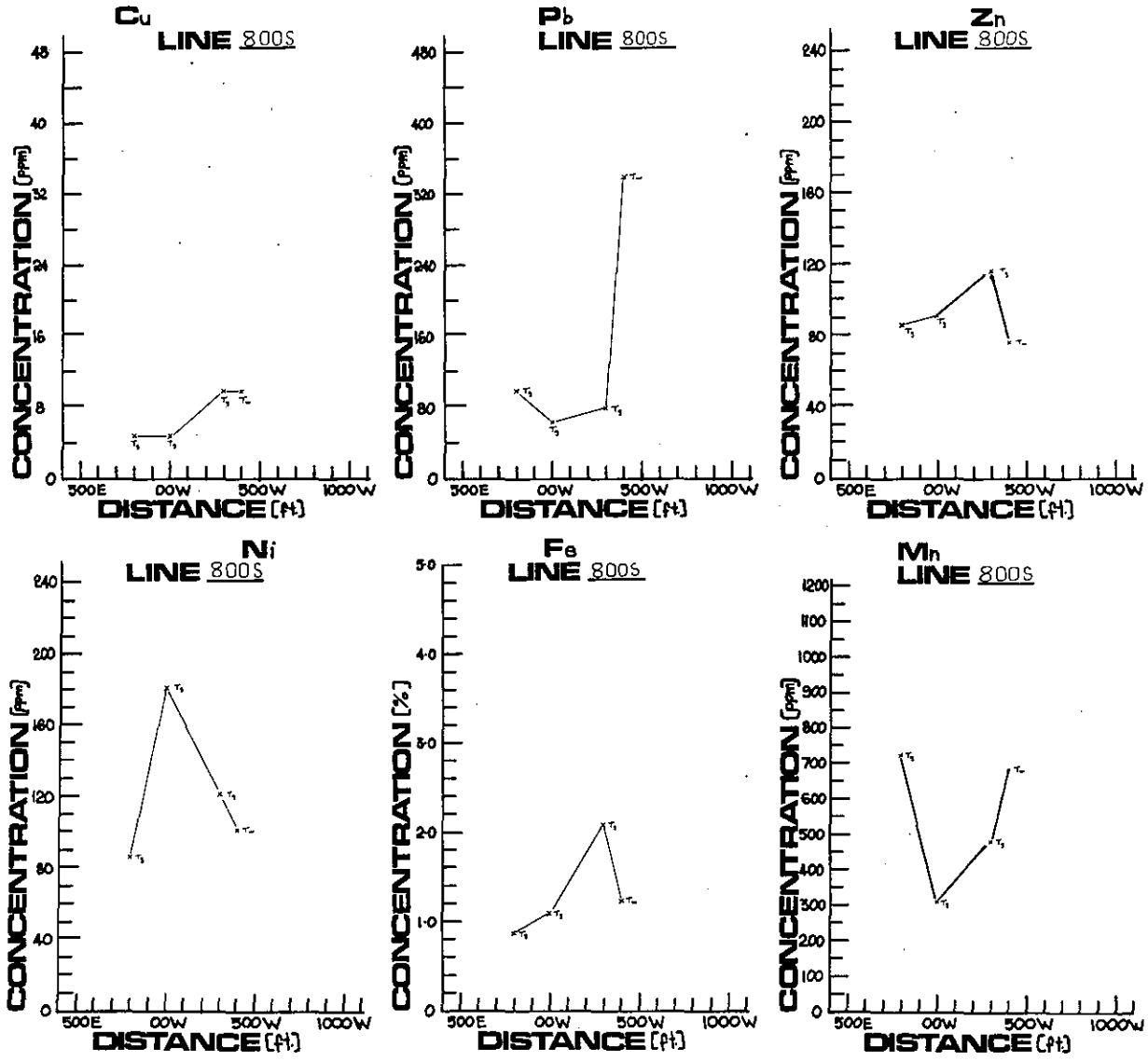


Figure: 2.31 Elemental Concentration along Cut Grid Line

Tw - White Siliceous Tuff
Tg - Green Sericite Tuff
S - Shale

PARENT ROCK SURVEY

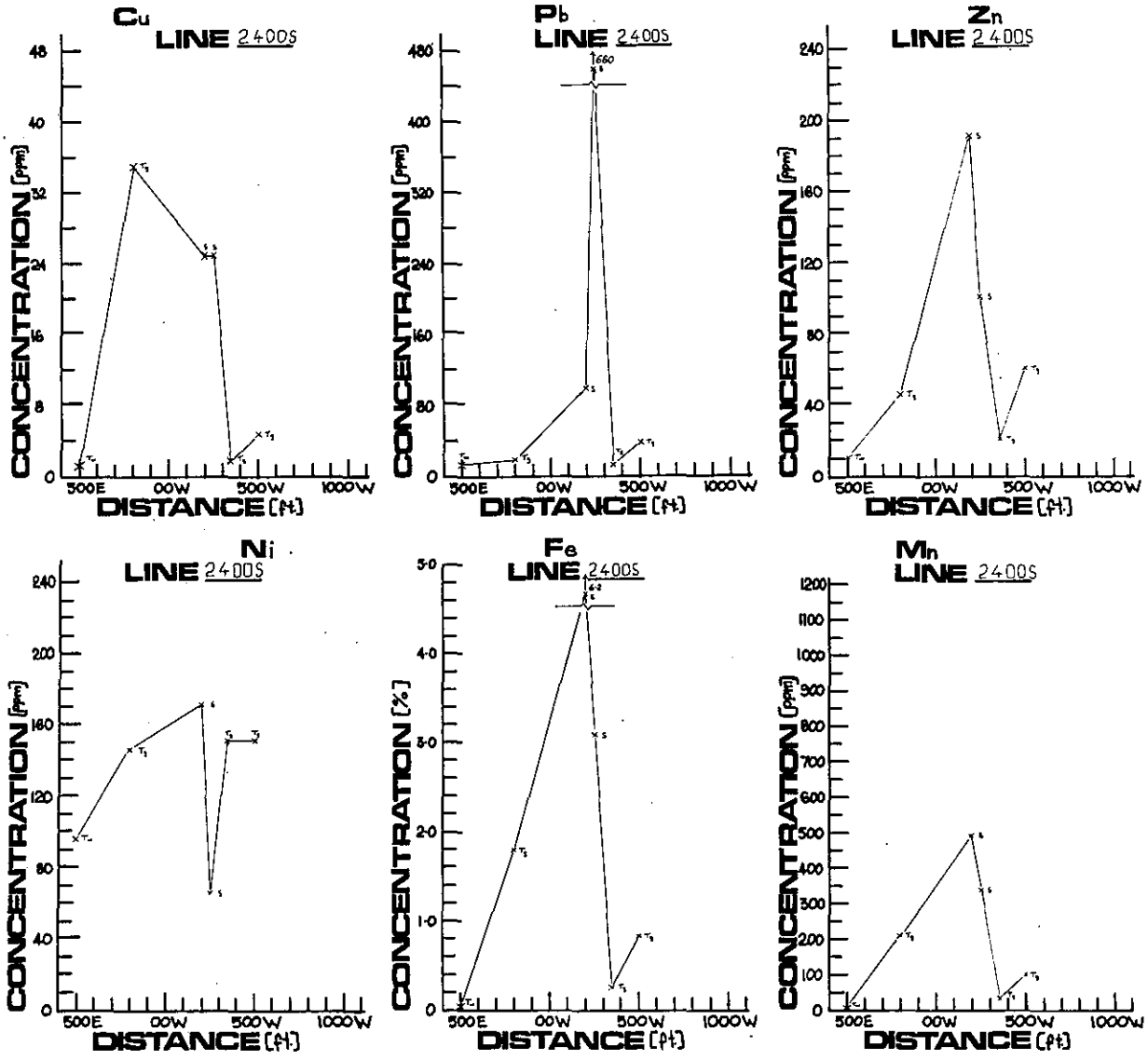


Figure:2.32 Elemental Concentration along Cut Grid Line

Tw - White Siliceous Tuff

Tg - Green Sericite Tuff

S - Shale

(iii) Exclusion Mechanisms.

The ability of a plant species to restrict its uptake of a toxic element is known as its exclusion mechanism. In such cases, the amount of the element in the aerial parts of the plant initially increases with an increase of the element in the soil. At a certain concentration of element in the soil, the element in the plant levels off at a "ceiling". Then, the amount of element in the aerial parts remains at a constant level whatever the amount of the toxic element in the soil. This exclusion mechanism ultimately breaks down at a certain threshold concentration of the element in the soil. Above this threshold, increased amounts of the element are accumulated over a short concentration range, until the amount in the soil is completely toxic to the plant. (Brooks, 1972).

A plot of element in plant ash against element in soils clearly illustrates this exclusion mechanism (Figure 2.33). For lead, it can be seen that, for up to 300 ppm soil-lead, there is a distinct linear relationship between plant-lead and soil-lead. After this, the graph tapers off to a near horizontal line, suggesting that Nothofagus cunninghamii has an exclusion mechanism which sets a general "ceiling" for lead concentration in the plant.

Fortunately, this exclusion mechanism does not interfere with the use of the plant for detecting soil anomalies, as any soil concentration above 300 ppm lead

LEAD CONCENTRATION IN NOTHOFAGUS (ASH) - LEAD IN SOIL

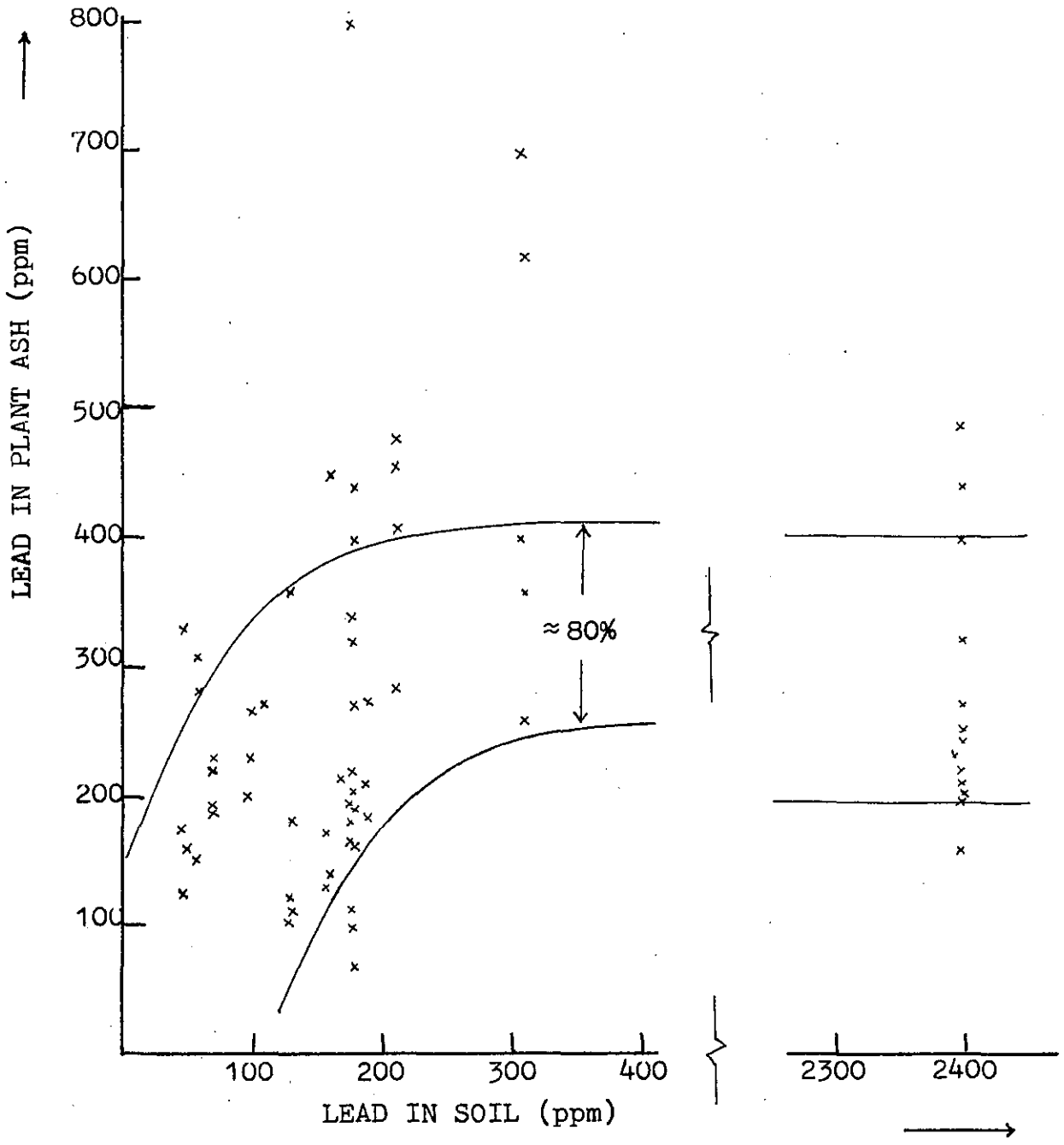


Figure: 2.33

would be worth further investigation.

Similar plots can be made of other toxic elements to illustrate the species exclusion mechanism.

(iv) Summary of Primary Results.

The preceding discussion has been summarised in table form (Figure 2.33a). The following is a coverage of the more salient points.

(a) Nothofagus cunninghamii. The lead values in the soil were accurately reflected by wood and leaf-copper; wood, bark and leaf-lead; and wood, bark and leaf-iron concentrations.

The most sensitive reflections were produced by copper and lead in leaves and iron in bark. Twigs were too erratic to be of any use at all for any element.

(b) Leptospermum nitidum. Perhaps the reason why this species does not appear to be as useful in reflecting the soil anomaly as the Nothofagus cunninghamii is that it does not occur over the major soil anomaly. Hence, it was tested over relatively minor anomalies and the results were not as conclusive.

However, the lead values in the soil were reflected by twig-copper; wood, twig and leaf-manganese; and twig, bark-barium and cadmium.

(c) Anodopetalum biglandulosum. There are only a few cases when this species can be used to reflect lead-soil values. These cases involve the use of twig-copper, twig-nickel, leaf-manganese and twig-iron.

(d) Exclusion Mechanisms. These do operate in the plant species, but at such a level that they do not interfere

with use of the plant in biogeochemical prospecting.

(v) Enhancement of Reflection.

(a) Rationale.

As there are probably up to twenty different variables which can effect elemental accumulation by plants, the accuracy of the plant reflection of soil values is indeed surprising. As previously mentioned, the use of suitable procedures such as controlled sampling can eliminate, or at least reduce the effects of most variables.

Another procedure which further reduces the effect of such variables as plant physiology, metabolism, root depth, pH, Eh, drainage, availability of elements and variable shading, was developed and used with success. This procedure involved the selection of an elemental ratio. The pair of elements used had to be of the same availability to the plants over the pH range encountered (Brooks, 1972).

The two pairs of elements chosen for enhancing the Nothofagus reflection of soil-lead, were the lead/nickel and iron/nickel ratios. The lead/nickel ratio in vegetation can be used, provided that the lead and nickel soil anomalies do not occur simultaneously. The lead anomaly has a peak value at 400N 700W while the minor nickel soil anomaly has a peak value at 400N 1125W (Figure 3.44).

A plot of nickel against lead concentration in soils is yet another method of illustrating the variability of the lead/nickel ratio (Figure 2.34).

(Figure 2.33a) PLANT ORGANS THAT REFLECT SOIL-LEAD CONCENTRATIONS IN PLANT ASH ELEMENTS

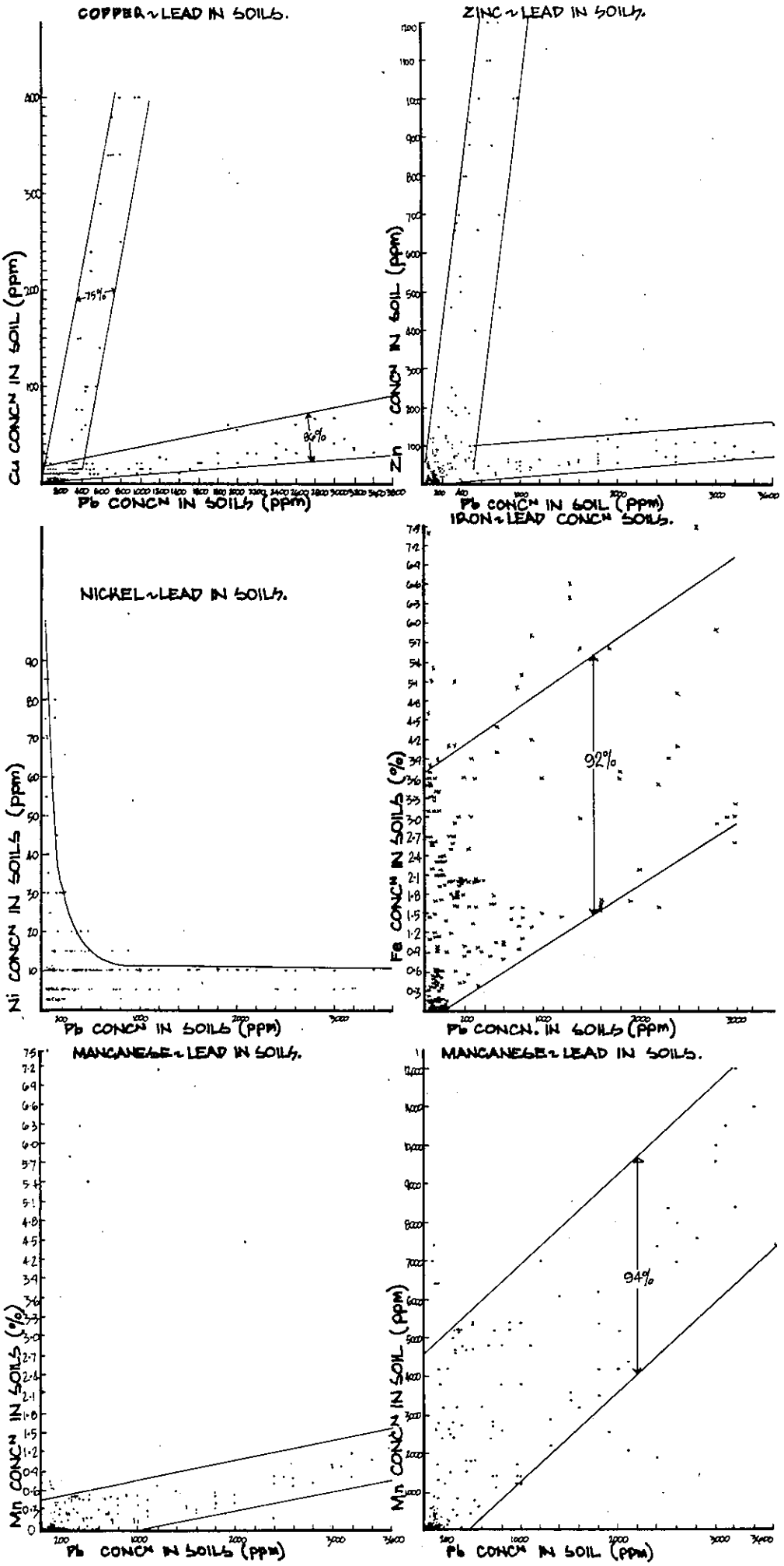
Species \ Element	* Cu	x Pb	* Zn	Ni	x Mn	x Fe	Cd	Ba
Nothofagus cunninghamii	Wood Leaves	Wood Bark Leaves	-	-	-	Wood Bark Leaves	-	-
Leptospermum nitidum	Twigs	-	-	Bark(?)	Wood Twigs Leaves	Twigs(?)	Bark Twigs	Bark Twigs(?)
Anodopetalum biglandulosum	Twigs	-	-	Twigs	Leaves	Twigs	-	-

* - Essential, biogeochemical elements.

x - Small enrichment coefficients.

Leaves and twigs are generally the most sensitive reflectors.

SOIL ELEMENTS PLOTTED AGAINST LEAD IN SOILS. Fig. 2.34



In this plot, soil-nickel remains constant at 10-15 ppm for all lead-soil concentrations above 300 ppm.

The peak values of soil-nickel and soil-iron occur at the same location, but the large values of iron completely "swamp" the relatively minor amounts of nickel present. Also, as it is the reflection of the soil-lead values by the plant-iron that is of interest, the relative location of the lead and nickel soil anomalies is of more importance.

The use of these elemental ratios means that, as the soil concentration of nickel is constant, any variation in plant ash concentration of nickel is purely a function of one or more of the previously mentioned botanical variables. Hence, these ratios should eliminate the affects of any botanical variables and thus enhance the accuracy, precision and clarity of the reflection of the soil anomaly in the plant ash.

The enhancement of the data using this technique is illustrated by the plot of the lead/nickel Nothofagus ratio against the lead concentration in soils (Figure 2.35). This strikingly linear graph also suggests a "ceiling", imposed by the plant's physiology, on elemental up-take above 300 ppm soil-lead.

(b) Results (Figure 2.36).

The Fe/Ni and Pb/Ni ratios of Nothofagus cunninghamii plant ash were plotted across the lead-soil anomaly. A glance at the lead-soil values down 400N (Figure 2.36) will show that the lead anomaly occurs between 600W and 1000W (along 400N), with a peak value at 700W. In these graphs, the Fe/Ni and Pb/Ni ratio

Pb/Ni RATIO FOR NOTHOFAGUS (ASH) - LEAD IN SOILS

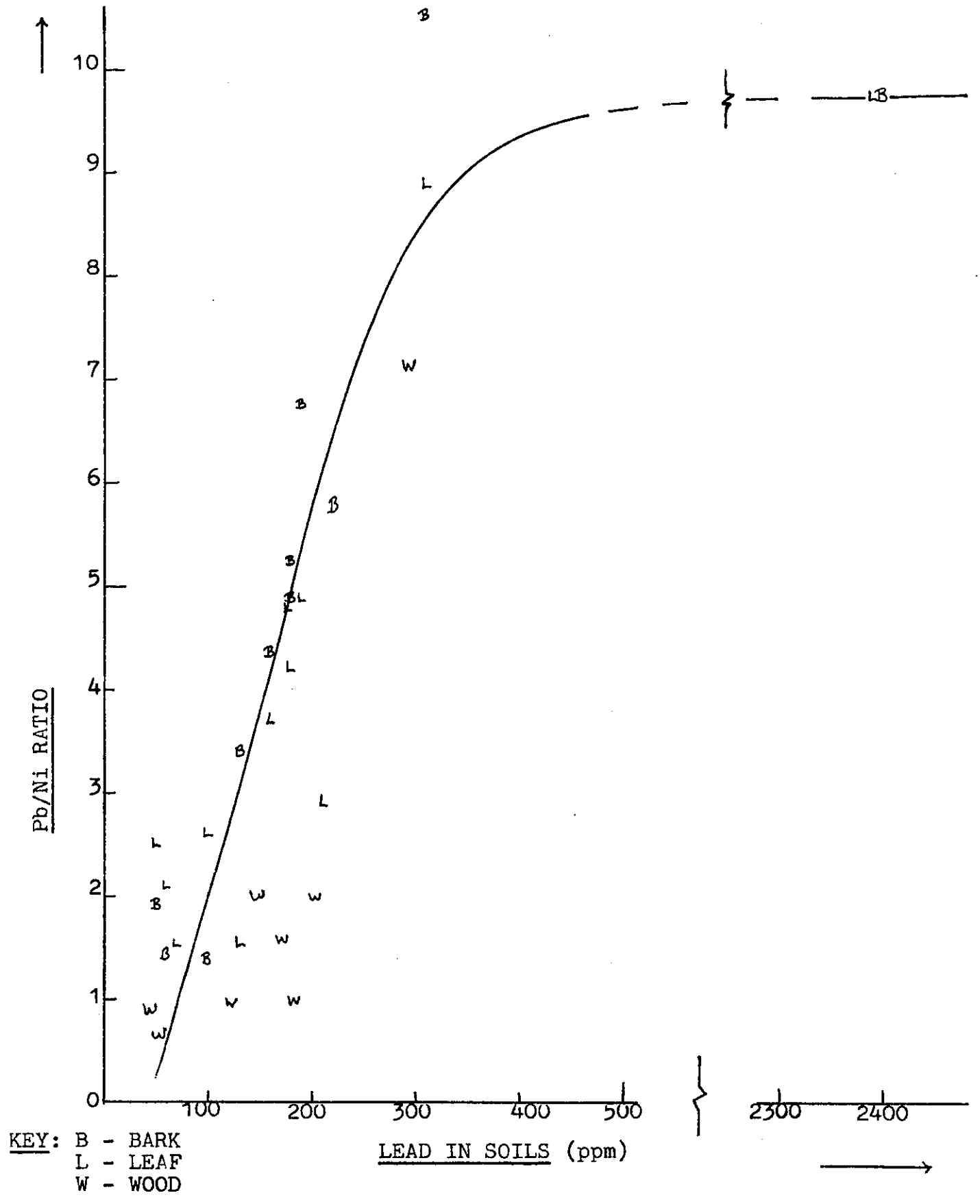
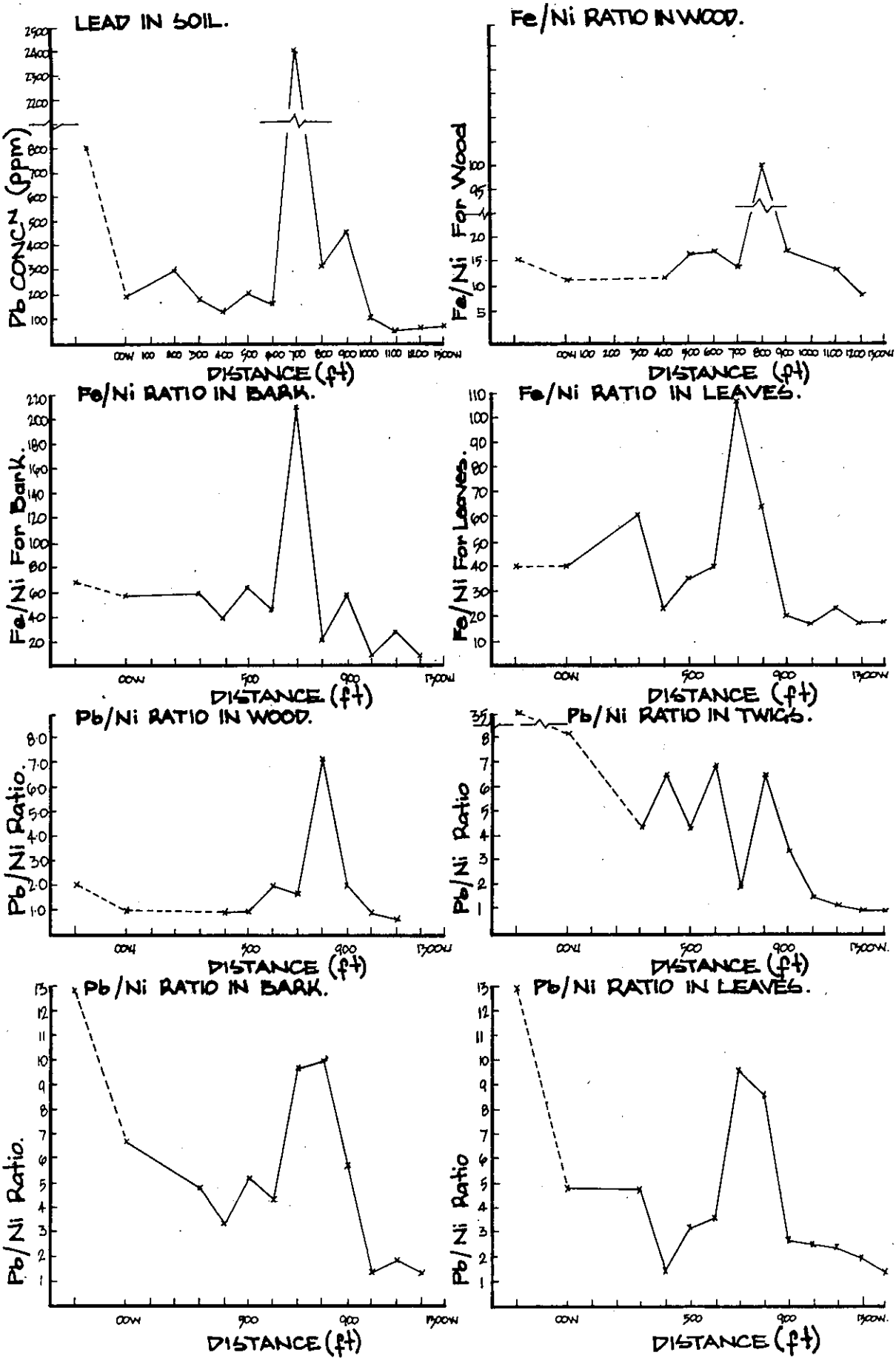


Figure: 2.35

ELEMENT RATIOS FOR NOTHOFAGUS CUNNINGHAMII (MYRTLE) ASH ALONG 400N.

FIGURE : 2.36



have both significantly improved the precision and clarity of the Nothofagus soil-anomaly reflection.

The accuracy and precision of the reflection by the Fe/Ni in Nothofagus bark is truely remarkable. The reflection by wood tends to be displaced downslope slightly, but the peak value in leaves and bark occurs at 700W. The plot for Nothofagus twig-ash is once again erratic, proving its unsuitability for biogeochemical prospecting.

Other plant-ash ratios have also been tried with some success. Space does not permit the plotting and discussion of them, but they have been expressed in table form (Figures 2.17 and 2.18).

(vi) Conclusions.

The most useful plant organ for biogeochemical prospecting in the West Hercules Area proved to be the young leaves of Nothofagus cunninghamii. The young twigs of Leptospermum nitidum and Anodopetalum biglandulosum could also be used successfully in biogeochemical work. It is fortuitous that these two plant organs were the most convenient to sample, separate, dry, crush and prepare for analysis.

Elemental ratios chosen for Nothofagus cunninghamii significantly improved the accuracy, precision and clarity of the reflection. Hence, if suitable elemental ratios can be found, it is recommended that they be used in biogeochemical prospecting.

2.7 TRIAL SURVEY.

(i) Method.

This trial survey was the logical step from the previous orientation surveys. The aim of the survey was to test the reflecting ability of Nothofagus cunninghamii across a soil anomaly in a different location. The cut line chosen was 800S. The leaves of Nothofagus cunninghamii were collected every 50 feet (if possible) from 100E to 1500W. The lead-soil anomaly down 800S occurs between 300W and 1000W, with the lowest values located between 500W and 600W. The hole 100E is situated on the second anomaly, upslope from the one of interest.

The plot of plant-lead displays a close correlation with soil-lead concentrations. Any concentration greater than 120 ppm in plant ash-lead can be taken as an indication of anomalous lead values in the soil. (Figure2.33).

The plot of plant-iron is more erratic, but a case can be made for it reflecting anomalous concentrations between 500W and 1500W.

When nickel is plotted it shows a distinct, steady rise in concentration from 500W to 900W followed by a sharp decrease. As this could indicate a change in nickel concentration down the line 800S, nickel cannot be used in the elemental ratios.

(ii) Discussion.

Unfortunately,the anomaly was of considerable lateral extent and hence the ratio of background to

TRIAL SURVEY

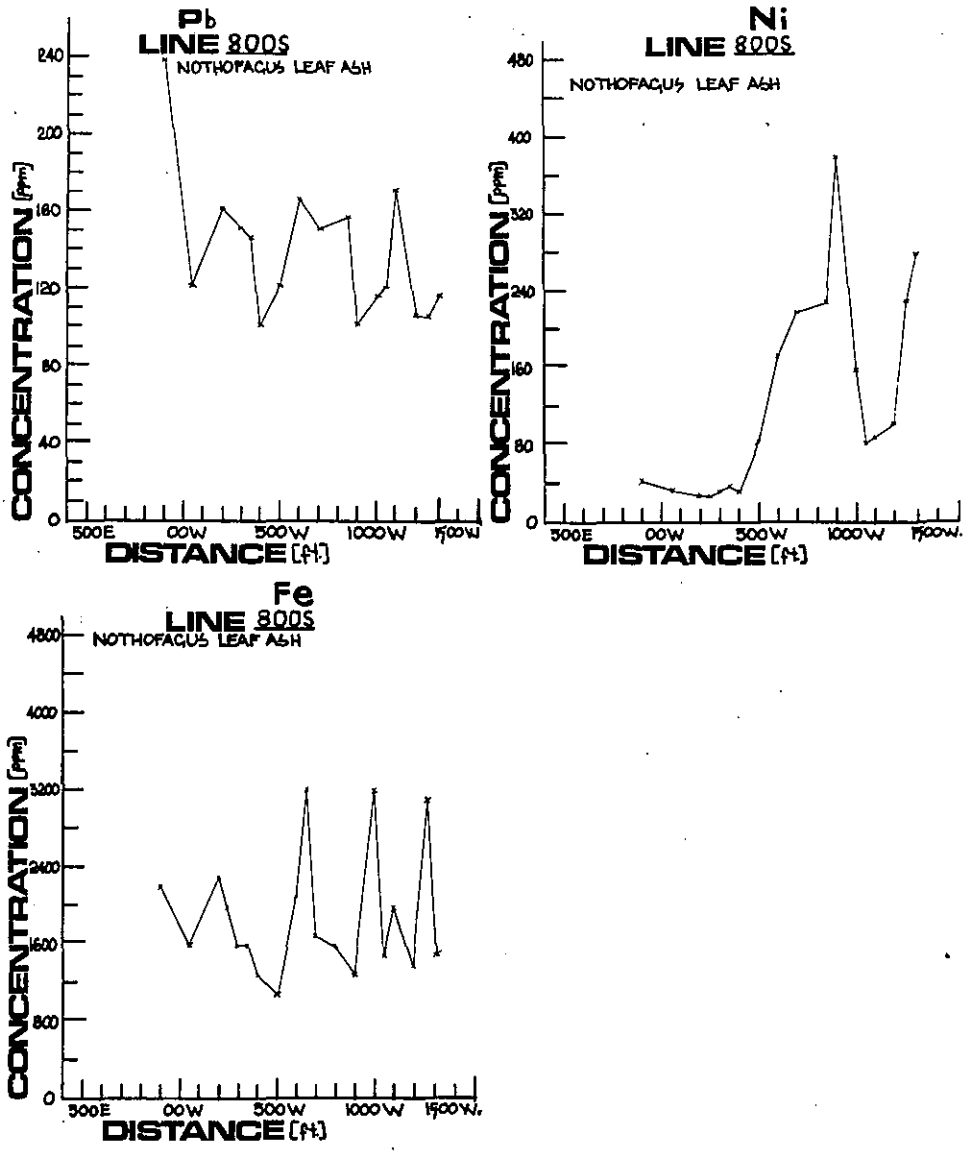


Figure: 2.37 Elemental-Leaf Concentration - Distance

anomalous soil values covered was not as high as it should have been. Even so, the lead soil anomaly was reflected by plant-lead, plant-iron and possibly plant-nickel. (Figure 2.37).

The anomalous values at 100E were reflected by both the plant-lead and iron concentrations. The low values at 00W and the high values between 500W and 900W were accurately reflected by the plant-lead and less clearly reflected by the plant-iron. Interestingly enough, the plant-lead, iron and nickel values reflect the small anomaly between 1400W and 1500W. This illustrates the ability of biogeochemical surveys to pick up anomalies of minor surface extent.

Hence, this independent trial survey has confirmed the ability of Nothofagus cunninghamii leaves to reflect the soil-lead values. Thus, biogeochemistry can be used to detect pedogeochemical anomalies in regions similar to the West Hercules Area.

2.8* LITTER SURVEY.

(i) Method.

The final aspect of the biogeochemical section involved taking composite samples of vegetation. The easiest method of obtaining a homogeneous, composite vegetation sample is to sample the litter at the soil-vegetation interface. Litter samples were taken from each soil-pit dug. Any inorganic matter was removed and then these samples were prepared and digested as vegetation samples.

The analytical data was plotted down the five lines sampled, with elemental concentration on the vertical axis (Figures 2.38to 2.41). The maximum soil concentration of each hole dug, was plotted on the same graphs for each element. The soil samples were indicated by "S" and joined with a thin dashed line.

(ii) Results (Figures 2.38to 2.41).

(a) Copper.

Soil-copper was generally not present in quantities sufficiently significant to enable any reflection. However, in the one line (800S) where it was present in significant quantities, there was a strong correlation between soil-copper and litter-copper.

(b) Lead.

Litter-lead accurately and precisely reflected soil-lead in all of the five lines sampled. The correlation between soil-lead and litter-lead was highly significant and looked the most promising of all the elements.

The litter-lead also correlated strongly with the parent rock-lead down the three lines 2400S, 800S and 400N. (Figures 2.30to 2.32).

LITTER SURVEY

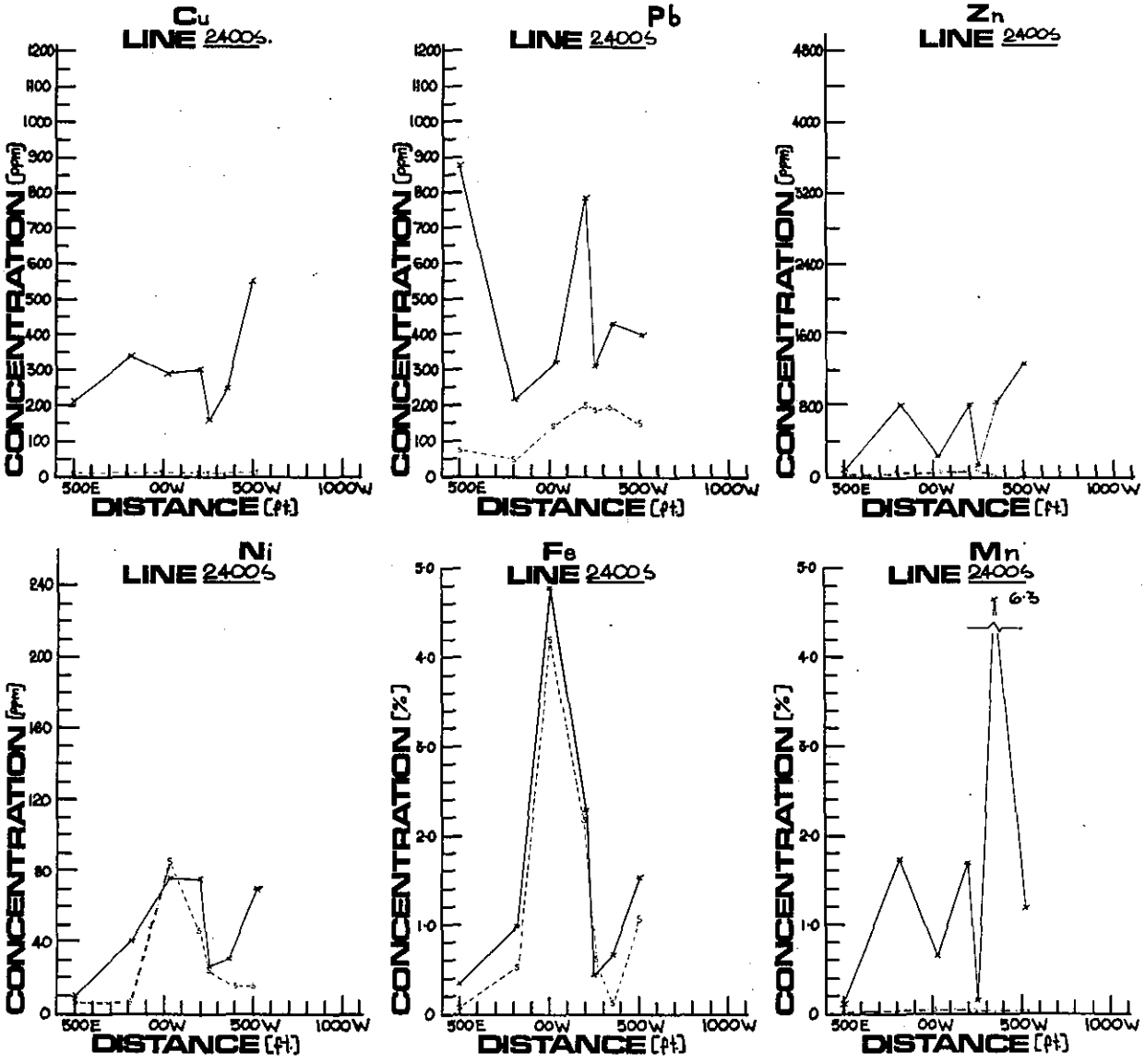
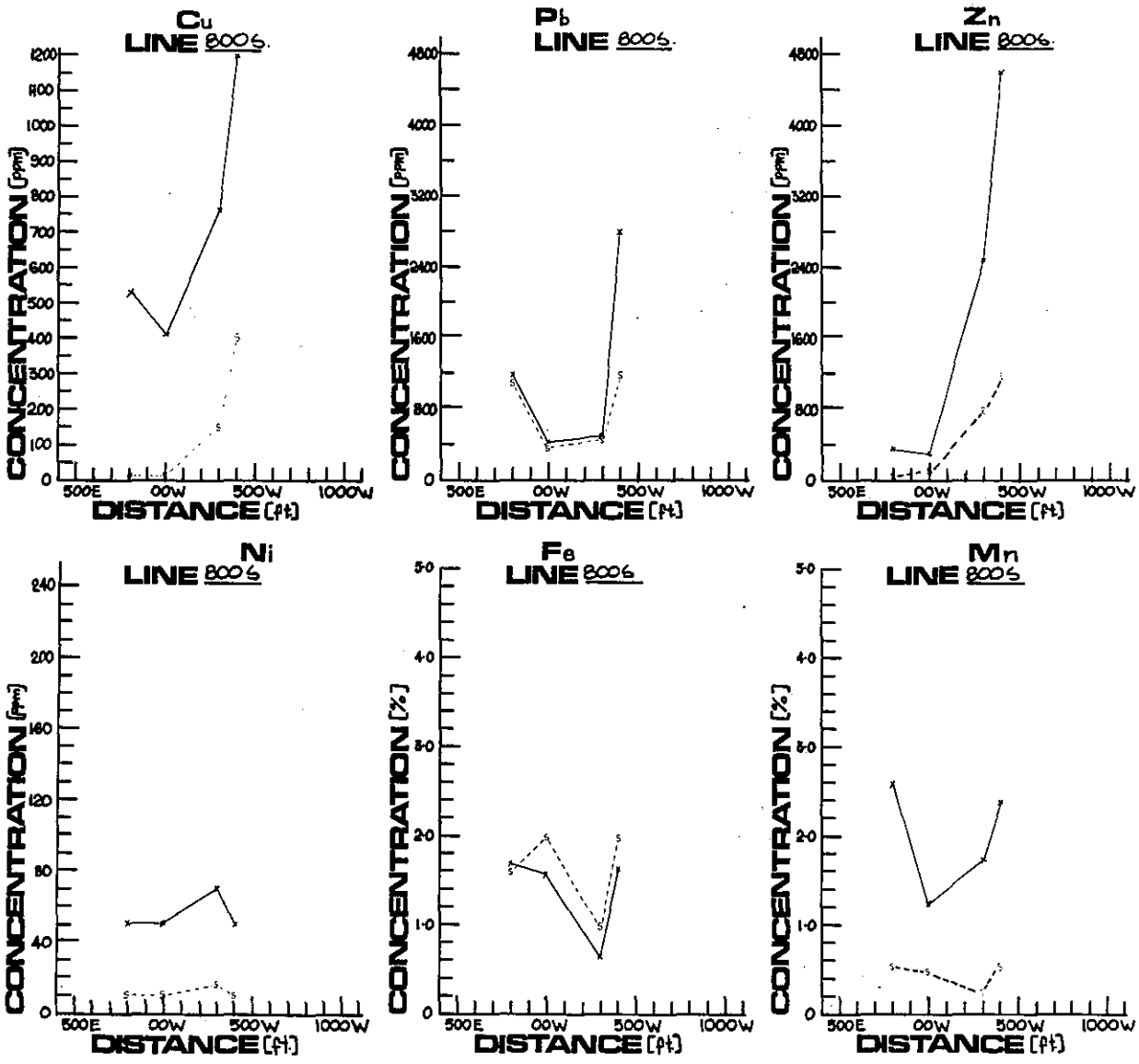


Figure: 2.38 Elemental Concentration - Distance

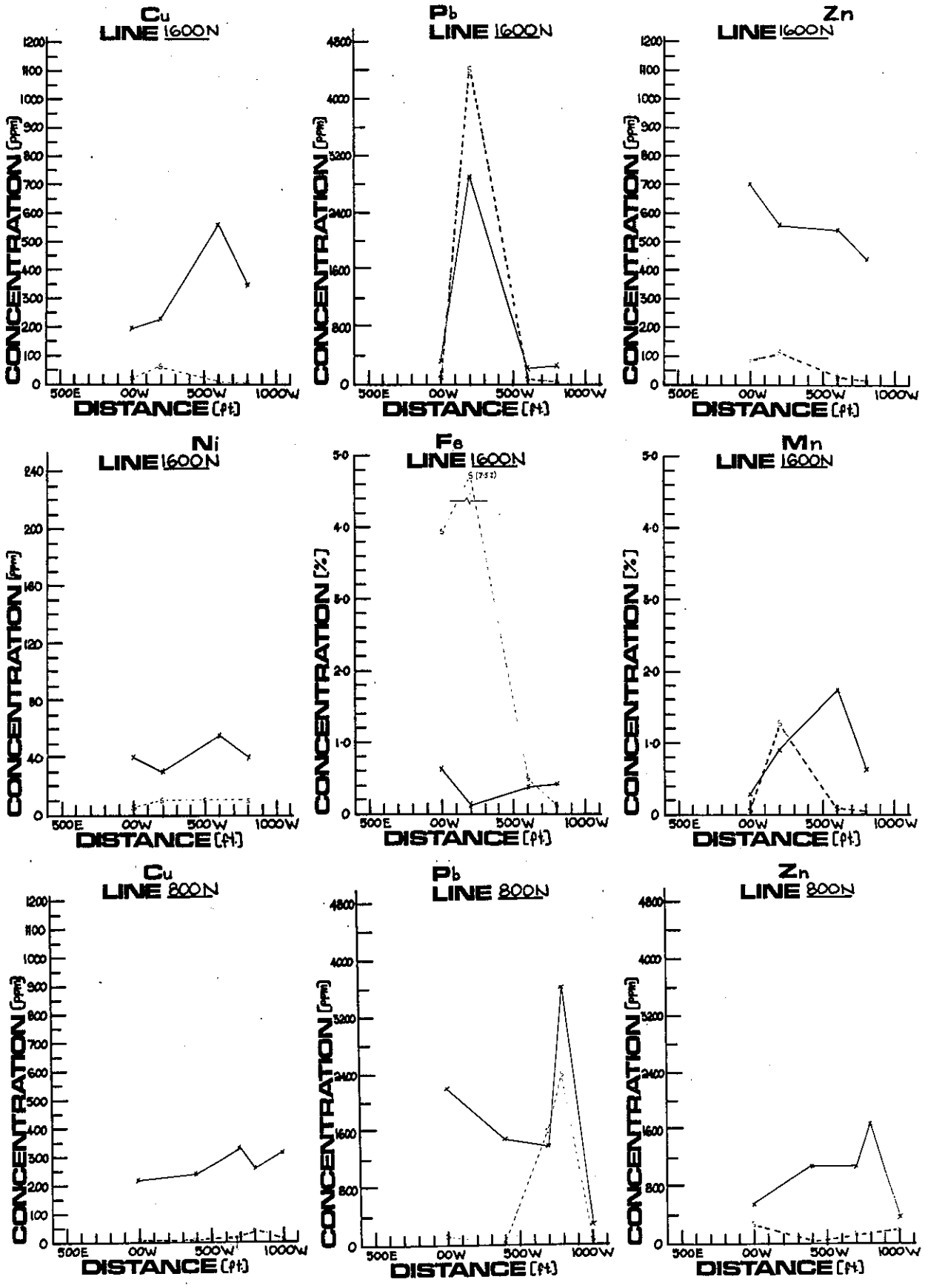
S - Soil-element x - Litter Element

LITTER SURVEY



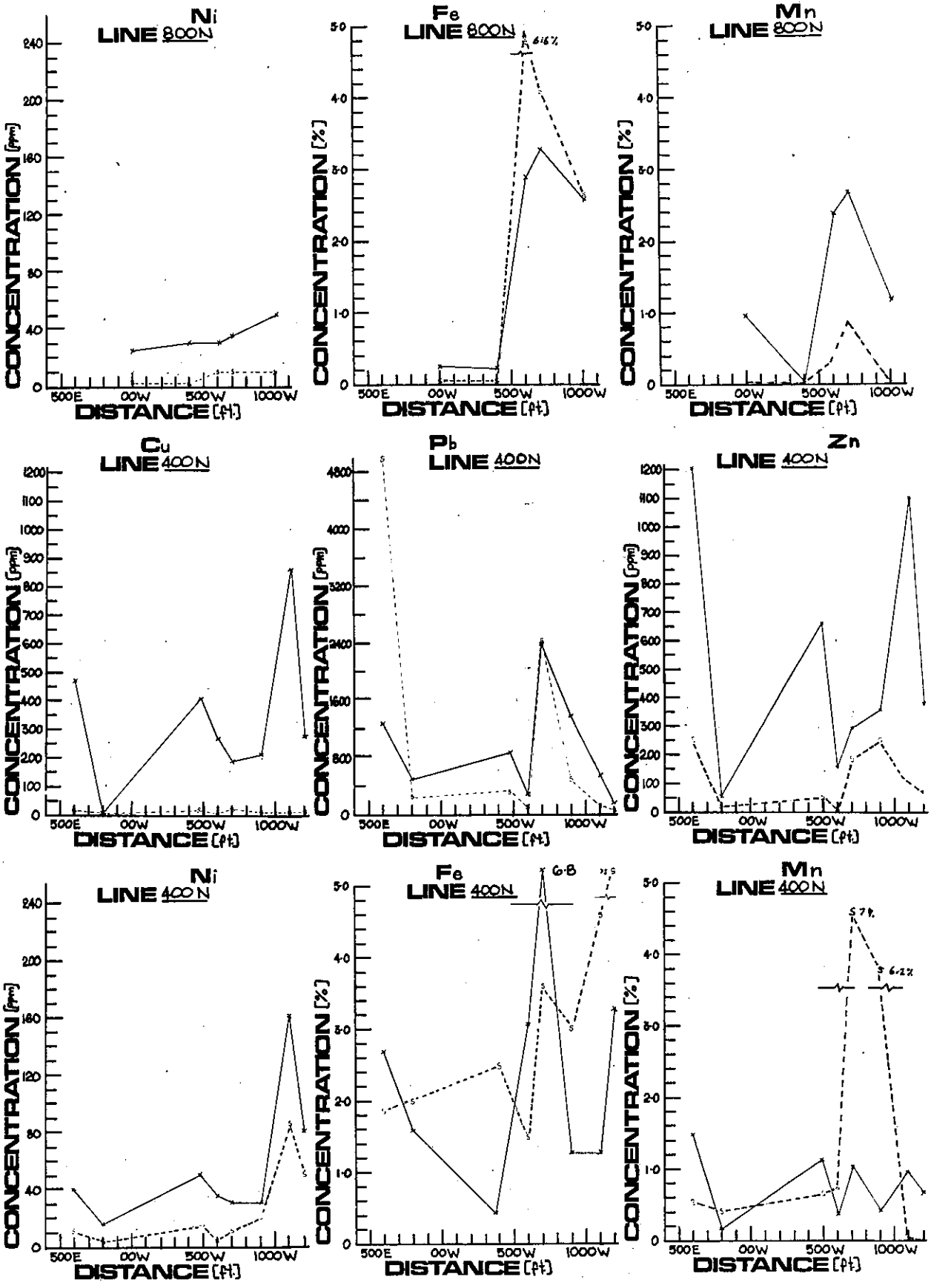
Elemental Concentration - Distance

Figure: 2.39 S - Soil-element X - Litter Element



Elemental Concentration - Distance

Figure: 2.40 S - Soil-Element X - Litter Element



Elemental Concentration - Distance

Figure: 2.41 S - Soil-element X - Litter Element

(c) Zinc.

Down two lines, soil-zinc was insignificant. However, the trends down the other three lines correlated strongly with the litter-zinc (800S, 400N and 1600N).

(d) Nickel.

Soil-nickel was present in significant amounts down three lines (2400S, 800S, 400W). There was a strong correlation between soil-nickel and litter-nickel down these three lines. Litter-nickel appears to follow parent rock-nickel along 2400S and 1600N.

(e) Iron.

In three cases out of five, litter-iron showed a very strong correlation with soil-iron. (2400S, 800S, and 800N). In the other two cases there was little or no correlation. The litter-iron down 2400S also reflects the parent rock-iron.

(f) Manganese.

This element was the least promising reflector. Only two lines (800S and 800N) provided litter and soil results that followed each other. Down the other lines, the litter-manganese was erratic. However, it appeared to follow the parent rock-manganese down lines 800S and 1000N.

(iii) Summary.

This particular biogeochemical survey proved to be extremely useful in reflecting soil-element concentrations. The results discussed in the previous section have been summarised in table form (Figure 2.42).

Lead concentrations in the litter were the most significant in reflecting the lead-soil values and the

FIGURE: 2.42 ELEMENTS IN LITTER THAT REFLECT MAXIMUM SOIL OR ROCK CONCENTRATIONS

Elements in Litter / Cut Line	Cu	Pb	Zn	Ni	Fe	Mn
2400S	(N/S)	SOIL ROCK	(N/S)	SOIL ROCK	SOIL ROCK	(N/S)
800S	SOIL	SOIL ROCK	SOIL	SOIL	SOIL	SOIL ROCK
400N	(N/S)	SOIL ROCK	SOIL	SOIL		
800N	(N/S)	SOIL	(N/S)	(N/S)	SOIL	SOIL
1600N	(N/S)	SOIL	SOIL	(N/S) ROCK		ROCK

KEY = (N/S) - Element concentration in soil not significant.

SOIL - Element in Litter strongly reflects maximum element distribution in soil down specified line.

ROCK - Element in Litter strongly reflects element distribution in rock, down specified line.

parent rock-lead concentrations.

When the soils contained significant amounts of the element, the copper, zinc and nickel contents of the litter correlated strongly with the soil-element concentrations.

Manganese and iron in the litter were the least consistent in reflecting soil-element concentrations. This is probably due to the mobilities of these elements when complexed with organic materials. Such complexing would be common in decomposing litter and would give rise to erratic results.

2.9 GENERAL CONCLUSIONS AND DISCUSSION

This section of the project has illustrated the feasibility of biogeochemical prospecting in the West Hercules Area. The results from this work would also be applicable to adjacent areas. However, these findings are only valid for the specific environment of the orientation survey.

As with all prospecting techniques there are advantages and disadvantages. These are discussed below.

(i) Advantages of Biogeochemical Prospecting.

In areas of thick vegetation cover, plant samples are far easier to collect than soil samples. This is especially the case if the ground is covered with litter, horizontal scrub, and intertwining roots. Where the topography is steep and rugged, many more plant samples can be carried out of the exploration area than can soil or rock samples, hence increasing field-work efficiency.

The trees of interest will have extensive root systems that can effectively sample a far larger volume of soil than could a single soil sample.

When soil sampling depends upon the selection of a particular soil horizon or depth for optimum efficiency, plant sampling is much simpler and more likely to be consistent.

If a soil contains high concentration of chemicals that cause interference problems during analysis, plant ash analysis may well not be effected.

The economics of soil verses plant sample preparation and analysis are much the same. Hence, the

technique with the most efficient sampling, would be the most economic. Plant sampling can prove to be speedier and less costly than soil sampling.

(ii) Disadvantages of Biogeochemical Prospecting.

Some may argue that plant sampling demands more skill and experience. However, once the field worker can recognise the few species of interest, this is no longer a problem.

This technique requires a complete cover of a particular species over the exploration area. Further more, the species of interest must be evenly distributed.

Unknown variables such as pH, drainage, aspect and organ age will affect the reliability of the method unless they can be controlled by sampling techniques and elemental ratios.

Biogeochemical prospecting in any region must be preceeded by an orientation survey. This is often more time consuming and more extensive than any pedogeochemical orientation survey undertaken for that area.

A distinct disadvantage is the scepticism with which many exploration geologists regard biogeochemical prospecting. This could be caused by the fact that biogeochemical methods are not invariably applicable where as soil sampling methods usually are.

Another disadvantage is that biogeochemical-prospecting samples material that is "twice removed" from the ore-rock of interest; while pedogeochemical-prospecting samples material that is only "once removed" from the ore. Each time the sampling technique moves a unit away from the ore rock, confidence in the reliability of that method is lowered.

Hence the greatest advantages of bio-geochemical prospecting are its penetrating power, ease of sample collection and portage.

The greatest disadvantages are the technique's variability caused by factors difficult to control and the necessity for uniform species cover of the area under investigation.

3. PEDOGEOCHEMISTRY

3.1 INTRODUCTION.

(i) General Theory.

The potential value in the chemical analysis of soils is based on the fact that, during the process of weathering and leaching, anomalous concentrations of elements may become incorporated in the soil from underlying or adjacent mineralization. Thus, a secondary dispersion halo is formed by the elements spreading outwards from the mineralization. This secondary environment is of the utmost importance in exploration geochemistry as the secondary halos are significantly larger than those in the primary environment. The term secondary dispersion pattern is defined by Levinson (1974) as "the distribution (or redistribution) or chemical elements in the surface zone of oxidation and weathering."

Secondary dispersion patterns are commonly displaced from the mineralization by one or more of four major factors. These are chemical, biological, mechanical and environmental factors. Depending upon which is the major influence, the resulting dispersion pattern may be classified as either a mechanical, hydromorphic or biogenic anomaly. Several different methods which can distinguish between these types of anomalies are covered in detail with reference to the West Hercules Soil Anomaly.

(ii) Scope of the Pedogeochemical Investigation.

This section of the project dealt with the linear soil anomaly at West Hercules (Figure 2.1). Thirty pits were dug and the soils were sampled at intervals, down to the parent rock. Parent rock samples were also taken.

These rock and soil samples were analysed for "total" Cu, Pb, Zn, Ni, Fe and Mn by Australian Laboratory Services, Brisbane, using atomic absorption spectrometry. A sequential analysis of four selected pits was undertaken at the University.

The primary aim of this section was to arrive at some explanation for the occurence of the soil anomaly at West Hercules. The three aspects of the anomaly investigated were the horizontal, vertical and chemical distribution of elements within the soils.

Possible controls of the horizontal distribution of elements were studied. These included Eh-pH controls, topographic control, parent rock, organic material and clay mineral controls.

The aim of studying vertical distribution and concentration of soil elements was two-fold. This would indicate both, which soil depth produced the clearest picture of the anomaly and which element - element associations were most prominent. The relationship between vertical distribution and soil maturity was also dealt with.

The chemical distribution of the soil elements Cu, Pb, Zn, Fe and Mn were determined using a sequential analysis technique modified from Gatehouse (1973). These analyses indicated the chemical location of the elements within the soil profile. They also were used to determine the effectiveness of the various scavengers present.

(iii) Project Area Description.

The soils in the West Hercules area range from shallow, skeletal immature soils (lithosols) on the upper

steep slopes to deep, well developed, mature podzolic soils on the lower, less steep slopes. The soils are neutral to acidic and the annual precipitation of the area is high (more than 250 cm p.a.) The organic matter content of the mature soils is high (up to 35% by weight) as is the clay content (up to 40% by weight) (Figures 3.45-6 and 3.47). The mature soils support a dense virgin rain-forest (Figure 2.6), while the immature soils are covered by low bushes and grasses.(Figure 2.3). The soils have developed on volcanogenic sediments, these being either a very siliceous crystal-tuff or green sericite crystal-tuff.

The major soil anomaly in the West Hercules area is approximately 1.2 kilometres long and up to 130 metres wide (Figure 3.1). It is distinctly linear, containing soil-lead concentrations up to 0.3% lead with less significant amounts of copper and zinc. The area contains three soil anomalies. The upper anomaly has been produced by downslope dispersion of elements from the adjacent Hercules host rocks and workings and is of little interest. The next anomaly is a relatively minor one and can be subdivided into three areas in which higher concentrations occur. The lowest, and most important anomaly, has the same linear trends as the others, but is more regular and consistant. This is the major soil anomaly of interest and will be the one referred to in the following sections.

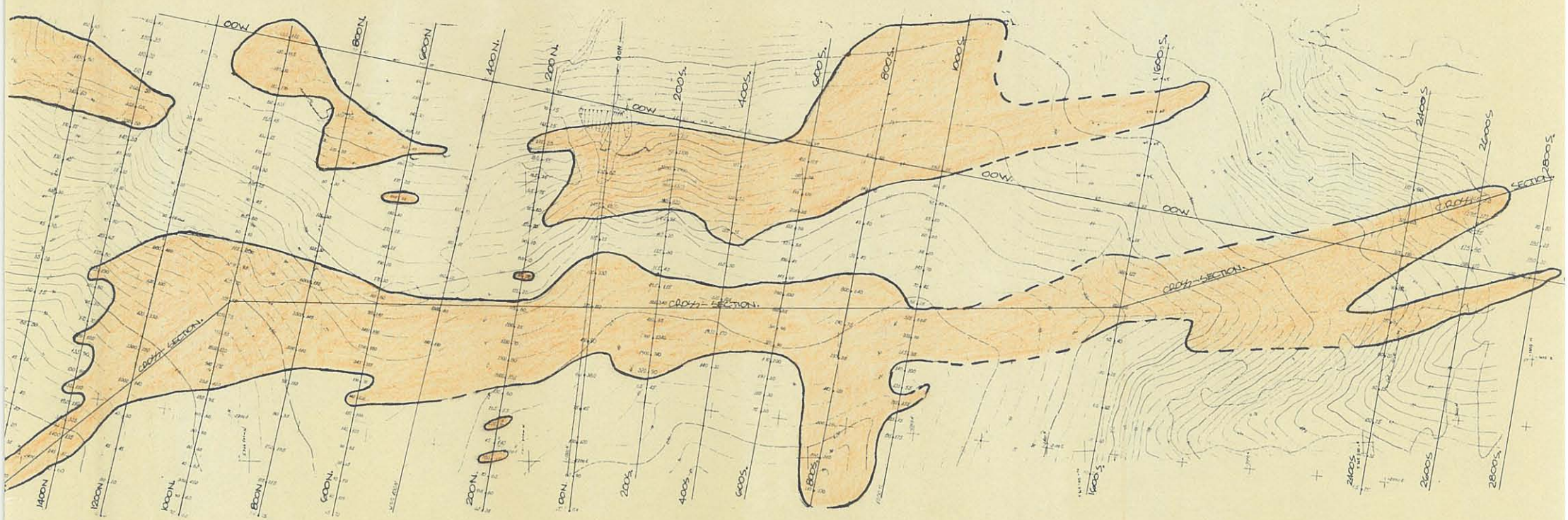
Rock outcrops only occur above this anomaly, on the steep, more exposed slopes. The only other rock exposures are those on the bulldozer-access track. An adit

"WHITE SPUR GRID - CUT LINES."

POSITION OF CROSS - SECTIONS DRAWN ACROSS GEOCHEMICAL LEAD SOIL ANOMOLY :-

Pb • Zn

SCALE 3 inches = 400 feet. FIGURE :- 3.1



has been cut into the hillside and several exploration trenches had been dug indicating past interest in mineralization in this area.

The adit is located on the middle anomaly and has been used as the reference point (OON, OOW) for the E.Z. Company exploration grid. Some dispersion is evident from the adit tailings.

3.2 SAMPLE COLLECTION.

(i) Sample Location.

The thirty pits dug were spaced over five grid lines that ran perpendicular to the soil anomaly (Figure 2.1). The grid lines involved were 2400S (7 pits), 800S (4 pits), 400N (9 pits), 800N (6 pits) and 1600N (4 pits). The spacing of the pits down each grid line was arranged so that the sample locations spanned the anomaly. About one-third of the pits were dug on the anomaly but, while the remaining two-thirds were off the anomaly, the background values for lead in the area were still rather high (45 to 150 ppm Pb, See Figure 3.1).

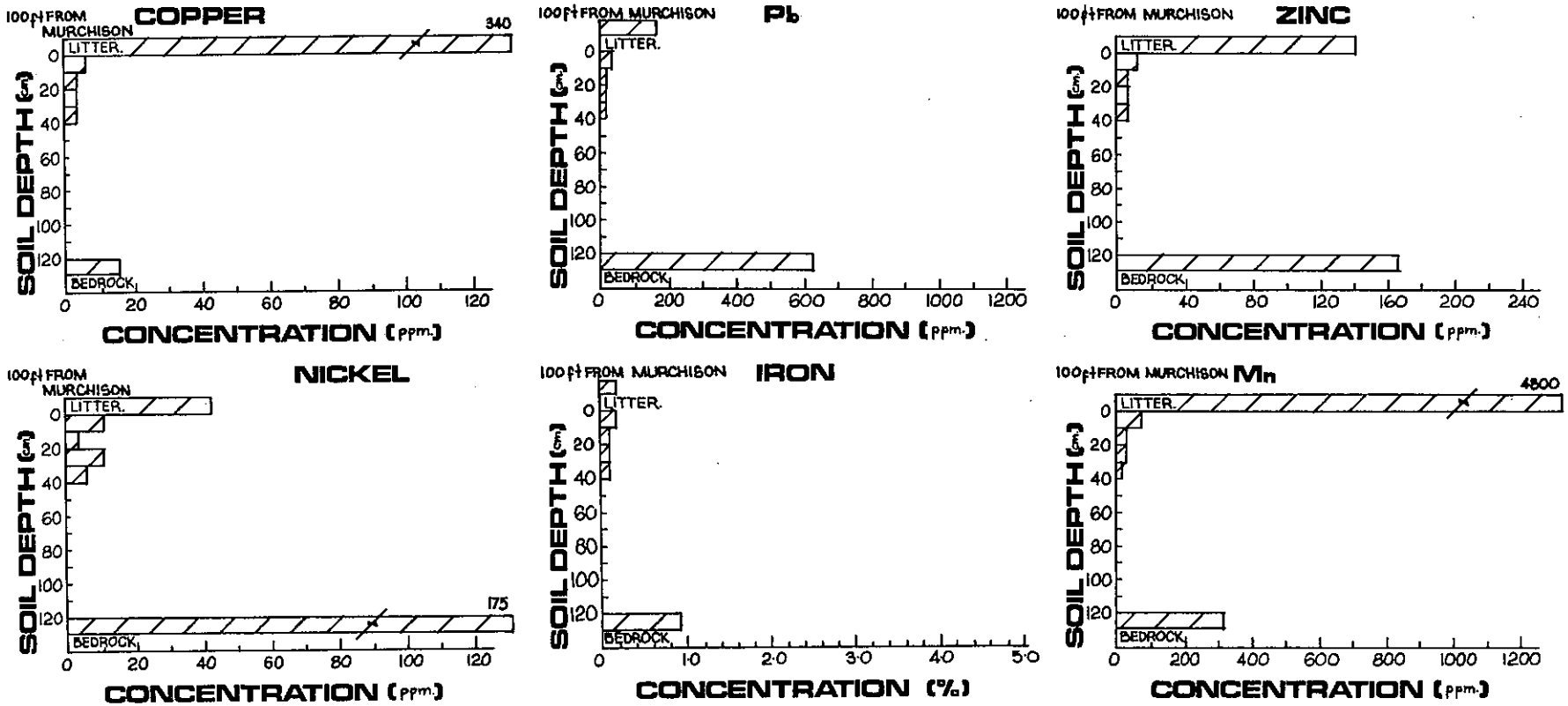
The sampling pits were dug to bed-rock and ranged in depth from 20 cm to 1.2 m. The pits were between 55 cm and 60 cm wide and had to be dug so that they drained freely. Drainage was a major problem as the soils were invariably water logged or saturated with groundwater. The most time consuming factor was the provision of adequate drainage for the holes dug. Probably the most efficient method of drainage would be to use a small hand-pump.

One sample pit was dug at the old Murchison Mine (South-east of Tullah) but the soil was so immature that it was of little value in reflecting any soil-element trends over an ore body. (Figure 3.2)

(ii) Sampling Method.

After the pits had been dug, the vertical face was cleaned, photographed and described. The sampling site was described, noting slope, predominant vegetation, rock type and any other feature of interest.

Figure: 3.2 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES



The vertical pit face was sampled every ten centimetres from the litter, to the bed-rock. These samples were placed in numbered, wet-strength paper sample bags and transported to the laboratory. With this close interval of sampling, care had to be taken to prevent contamination from the soil above the sample point. A representative sample had to be obtained and all large pieces of partially decomposed parent rock removed.

The description and photograph of each sample pit dug follows in the second volume, the Data Volume (Figures 3.3 to 3.32, pages 194 to 224).

3.3 SAMPLE PREPARATION.

(i) Discussion of Method. (See Appendix A.2 for details).

The main processes in preparing the samples were the drying, crushing, grinding and splitting of the soils.

The samples were spread out on trays and air-dried for two days in a special soil-drying room at the Mt. Pleasant Laboratories (Agricultural Department, Launceston). As some of the clay-rich samples had hardened into lumps, all the samples were crushed, using two horizontally mounted rollers driven by an electric motor. At this stage the pieces of organic matter and parent rock present were removed by sieving.

The samples were then ground in a "Hobart Cadet" electric soil grinder (Figure 3.33) to a maximum grain size of 1 mm. The larger samples were halved using a riffle sampler and then stored in wet-strength paper sample bags.

Those samples analysed for trace elements by X R.F. were ground to a fine powder using the ring-mill and pressed into pills. The air drying of soils has to be approached with caution as it causes changes in the chemical and physical characteristics of a soil. However, these can be minimized by carefully controlling soil drying parameters. The optimum temperature used was 28-32^{o}C with a humidity between 30 and 70%. As the degree of the changes varies with these parameters, the procedure for the air-drying of the soil samples was standardized.

Air-drying will also increase the exchangeable

Figure: 3.33 "Hobart Cadet" Electric Soil Grinder. The outside vertical plate rotates on motor shaft and soil is ground between the two plates of specially hardened metal. The distance between the plates and hence the maximum grain size, is controlled by the knurled knob.

manganese present in the soil. This increase has been explained as being due to oxidation of iron (II) with the simultaneous reduction of higher oxides of manganese. (Hesse, 1971).

Physical changes produced by air-drying are most evident in clay-rich soils that have been subject to excessive rainfall. The drying produces an irreversible dehydration resulting in the cementation of the clay particles.

This was one reason why the total sample was crushed and then ground for analysis. These soils dried in lumps which had to be ground-up and could not removed by sieving, otherwise a sample-bias would have been introduced.

The plant rock samples were cut for description and cleaned. They were then crushed by jaw-crusher and powdered by ring mill.

(ii) Analytical Precision.

As with the biogeochemical samples, soil samples were randomly resubmitted for analysis as a check on analytical precision. The results of these check samples are shown in the following table (Figure 3.34). It can be seen that an excellent precision has been attained with the analysis for copper, lead, zinc and nickel. Also, with the exception of one or two cases, very good analytical precision has been attained with iron and manganese.

Both the soil crusher and grinder were tested for the amount of heavy metal contamination they

CONTAMINATION AND PRECISION TESTS ON SOIL ANALYSES (ppm)

Test	No.	Cu	Pb	Zn	Ni	Fe	Mn
Check Sample	145	2	70	15	10	0.12%	20
	146	2	70	10	10	0.13%	20
	151	2	120	25	10	0.92%	25
	152	2	120	35	10	0.92%	20
	201	150	360	680	10	1.95%	0.52%
	202	150	380	700	10	2.0%	0.52%
	204	70	1.20%	80	5	1.75%	0.46%
	205	70	1.20%	85	5	1.75%	0.50%
	213	2	150	10	5	2.3%	0.28%
	214	2	130	10	5	2.3%	0.26%
	232	30	0.21%	170	10	1.70%	0.21%
	233	30	0.22%	170	10	2.2%	8.6%
	248	10	40	70	80	3.6%	110
	249	10	35	65	80	3.5%	110
	275	10	0.11%	45	10	5.8%	0.29%
	276	10	0.11%	45	10	4.2%	0.22%
Mortar & Pestle Grinder	278	15	0.15%	60	10	6.6%	0.36%
	277	15	0.15%	55	10	6.4%	0.34%
Mortar & Pestle Grinder	273	10	740	30	5	4.0%	0.11%
	272	10	740	30	5	4.4%	0.14%
Mortar & Pestle Grinder	159	15	0.10%	35	10	1.15%	0.38%
	160	15	0.11%	40	5	1.30%	0.48%
Crusher	325	5	10	20	5	0.20%	25
Hand Sieved	326	2	10	10	5	0.16%	20

Figure: 3.34

contributed to the soil samples. The test for the "Hobart Cadet" soil grinder involved mixing a soil sample, and splitting it. One sample half was ground by hand, using a porcelain mortar and pestle and the other half was ground using the electric grinder. A comparison of the two samples (Figure 3.34) showed contamination of only iron (0.25%) and manganese (500 ppm) by the electric soil grinder.

The soil-crusher contamination was tested in a similar fashion (Figure 3.34). One sample half was hand crushed and sieved, the other half was crushed with the electric rollers and sieved. The subsequent analyses showed a contamination of only iron (400 ppm). The general contamination of iron and manganese did not produce a very high background in the samples, as values as low as 400 ppm and 10 ppm (respectively) have been recorded in the analytical data. However, these contamination and precision tests for the soils indicated the possible confidence level for the interpretation of the analytical data.

In order to produce a homogeneous sample for analysis it is usual to conduct an extensive and tedious mixing procedure. However, it was felt that by the time the soil samples had reached the splitting stage, they had been sufficiently homogenised by the crushing, sieving and grinding processes. In order to test this assumption, a mixing test was conducted. In this test ground samples were halved and one half was analysed as

SOIL ANALYSES

Mixing Test:	No.	Cu	Pb	Zn	Ni	Fe	Mn
Unmixed	165	10	300	45	10	1.65%	0.28%
Mixed	166	10	300	45	10	1.65%	0.24%
Unmixed	167	15	380	15	10	1.80%	0.27%
Mixed	168	10	340	40	5	2.0%	0.32%
Unmixed	170	20	500	85	10	2.0%	0.54%
Mixed	169	15	440	65	10	2.0%	0.47%
Unmixed	171	15	340	75	5	1.95%	0.52%
Mixed	172	15	360	80	5	2.0%	0.52%
Unmixed	173	15	330	75	10	1.85%	0.47%
Mixed	174	15	320	75	10	1.75%	0.46%
Unmixed	175	15	300	190	5	1.75%	0.50%
Mixed	176	15	320	70	5	1.80%	0.52%

Figure: 3.35

the "unmixed" sample. The second half was thoroughly mixed and then analysed as the "mixed" sample (Figure 3.35). The results showed that there was no justification for the tedious mixing procedure after the samples had been crushed, sieved and ground.

Some parent rock samples were also resubmitted for analysis as random checks on analytical precision. In general the precision obtained was satisfactory. (Figure 3.36).

CONTAMINATION AND PRECISION TESTS ON PARENT ROCK ANALYSES (ppm)

No.	Cu	Pb	Zn	Ni	Fe(%)	Mn
363	25	100	190	170	6.2	490
395	25	120	190	200	6.2	520
Variation	0%	17%	0%	15%	0%	6%
367	5	65	90	180	1.10	310
396	2	50	90	85	1.30	280
Variation	(60%)	8%	0%	53%	15%	10%
369	10	340	75	100	1.25	680
397	5	320	75	100	1.25	680
Variation	(50%)	6%	0%	0%	0%	0%
370	40	220	90	65	2.4	30
398	35	200	80	70	2.2	25
Variation	(12%)	9%	11%	7%	8%	(17%)
382	260	400	0.26%	140	6.2	25
399	260	380	0.26	135	5.3	30
Variation	0%	5%	0%	4%	15%	(17%)
360	25	660	100	65	3.1	340
400	20	520	95	50	3.0	280
Variation	(20%)	21%	5%	23%	3%	18%

Figure: 3.36

(x%) = Variation not significant as difference of analyses close to detection limit.

Variation expressed as a percentage of higher concentration.

3.4 ANALYTICAL PROCEDURES

The E.Z. Company funded total soil, rock and plant analyses done by the Australian Laboratory Services, Woolloongabba, Brisbane. The analytical techniques used by A.L.S. are outlined in Appendix A. A few samples were analysed by X-Ray Fluorescence Spectrometry in order to check the accuracy of the A.L.S. 'total' soil analyses. The results for lead are listed below:-

Sample Number:	226	229	234
X.R.F. analysis (Pb)	1366 ppm	1785 ppm	1281 ppm
A.L.S. 'total' Pb	1200 ppm	1800 ppm	1200 ppm

The agreement between the two analyses is acceptable and indicates that the A.L.S. extraction techniques removed almost all the element for analysis.

The two main analytical procedures developed were the sequential analysis of soils and the analysis for total carbon in soils. These are discussed below.

(i) Sequential Analysis of Soils (see Appendix B.1 for details).

The analytical system of progressive leaching of soils (Gatehouse, 1973) was modified and applied to samples from four pits. Those chosen were 400N 225W, 400N 700W, 400N 1125W and 800N 700W. The hole 400N 225W was shallow, immature and situated on the steep slopes above the anomaly. The holes 400N 700W and 800N 700W were located on the anomaly in deep, mature soils.

The pit 400N 1125W was shallow and situated below the soil anomaly.

The sequential analysis makes it possible to locate the distribution of metals over the various soil phases (i.e. water extractable, reducible manganese, organic material, reducible iron, clay and residue phases). The principle of sequential soil analysis is that each succeeding extraction is more aggressive and hence the metallic elements are extracted in order of their tenacity (Jackson, 1956).

The sequence involves six extractions. (Figure 3.3) These are:- (a) water extraction , (b) hydroxlamine extraction (c) hydrogen peroxide extraction (d) hydrazine chloride extraction and finally (e) a clay and (f) residue perchloric extraction.

(a) Distilled Water Extraction.

The distilled water was acidified to soil pH 4.5. In addition to increasing the mobility of elements originally dissolved in soil water, the acid acted as a floculant. But for this action, problems would have been experienced in decanting the supernatant, without removing the colloidal clay. This extraction removed the water soluble components of the soil.

(b) Hydroxylamine Hydrochloride Extraction.

The manganese reduction with hydroxylamine hydrochloride (Chao, 1972) was performed with buffered nitric acid, which results suggest, was too acidic. Therefore, it is recommended that in future, the extraction be performed with 0.1 M ammonium acetate. As this method

SEQUENTIAL ANALYTICAL SCHEME (After Gatehouse, 1973).

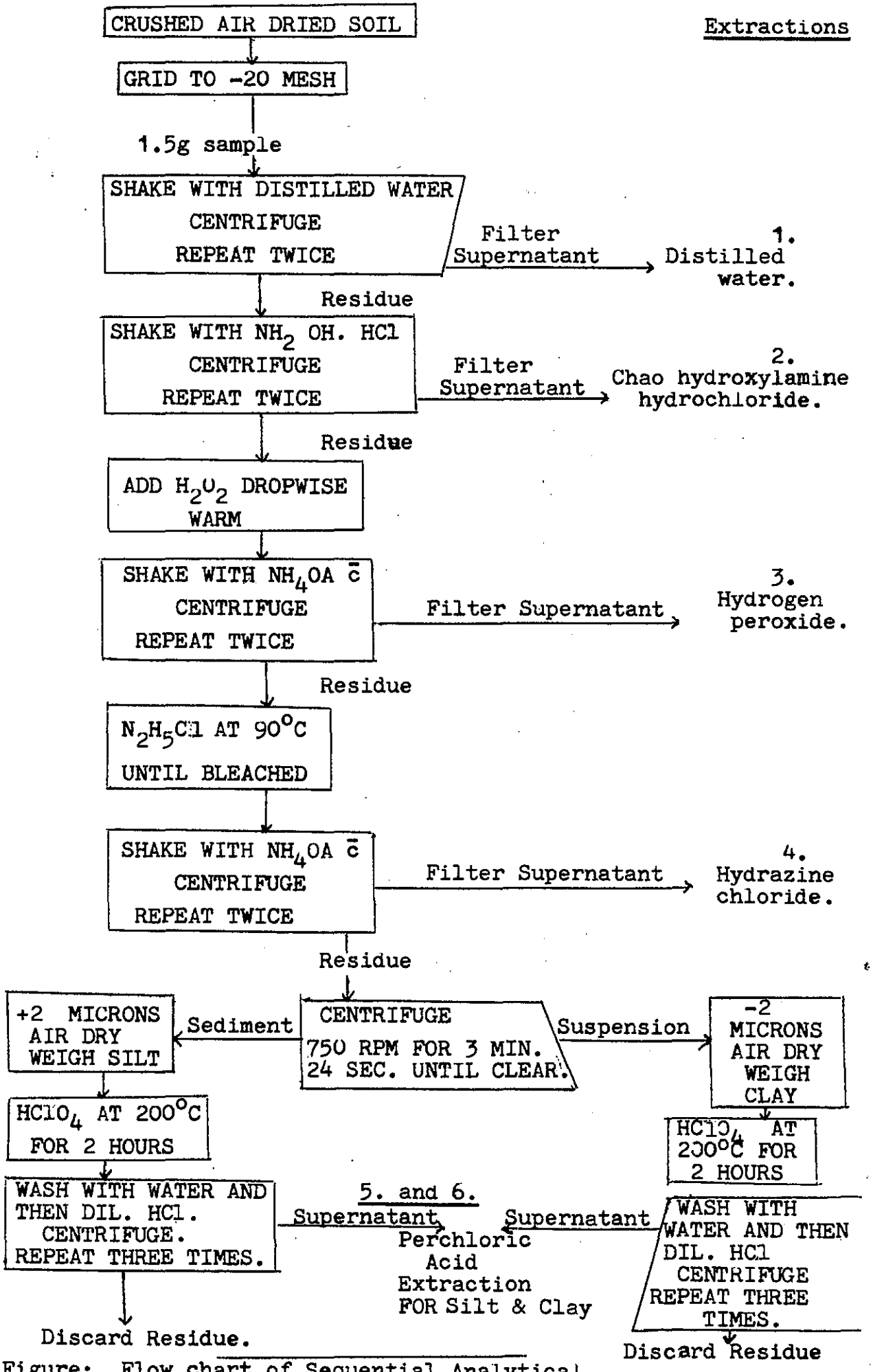


Figure: 3.37 Flow chart of Sequential Analytical Scheme for trace element extractions from soils.

extracts some iron, the extractions were limited to three extractions of 25 minutes each. The hydroxylamine hydrochloride removed both the exchangeable and reduceable manganese. The heavy metals released during the dissolution of the manganese oxides were prevented from forming insoluble hydroxides or basic salts through hydrolysis, by the low pH.

Discrimination of the exchangeable and reduceable manganese is desirable and could be obtained if an ammonium acetate extraction was conducted prior to the hydroxlamine extraction. The former would extract the exchangeable manganese and the latter would extract the reduceable manganese.

(c) Hydrogen Peroxide Extraction.

Hydrogen peroxide was used to destructively oxidize the soil organic material and release those metals complexed or chelated with the organic material. The released metals were prevented from sorption on the clays by the presence of ammonium acetate.

(d) Hydrazine Chloride Extraction.

Gatehouse (1973) developed a hydrazine chloride extraction which removed secondary iron oxides and occluded metallic elements from soils. He found that this technique did not significantly attack primary silicate phases. The extraction was continued until the samples were bleached, indicating complete removal of free iron oxides. The trace elements thus released were prevented from sorption on clays by the presence of ammonium acetate.

(e) Clay and Silt Separation.

Centrifugation was used to separate the clay (less than 2 microns) from the silt and residue (greater than 2 microns), after the hydrazine residues had been suspended in water. (Jackson,1956). As the main control over the separation of the clay and silt was the time of centrifugation, great care was taken to keep this time standard for all samples. This included using the greatest deacceleration force possible, for all samples. The temperature and time between centrifugation and decantation were also kept constant as these parameters influence the settling out of the silt.

The process was repeated until the supernatant was clear and free from colloidal clay.

(f) Perchloric Extractions.

These perchloric extractions of the silt and clay fractions were the final extractions in the sequential analysis. The perchloric acid released metals that were substituted into the structures of, or were secondary or primary minerals. The main disadvantage in grinding the soils whole and not sieving them into a coarse and fine fraction, lay in the fact that the silt-residue perchloric analyses tended to swamp the other values. This effect could be reduced graphically by scaling down the perchloric values, or by graphing them separately.

(ii) Organic Carbon Determination (See Appendix B.2 for details).

Carbon can occur in one of three forms in soils. The elemental and inorganic (carbonate) forms were of little importance in this project as they were not present

APPARATUS FOR DRY COMBUSTION

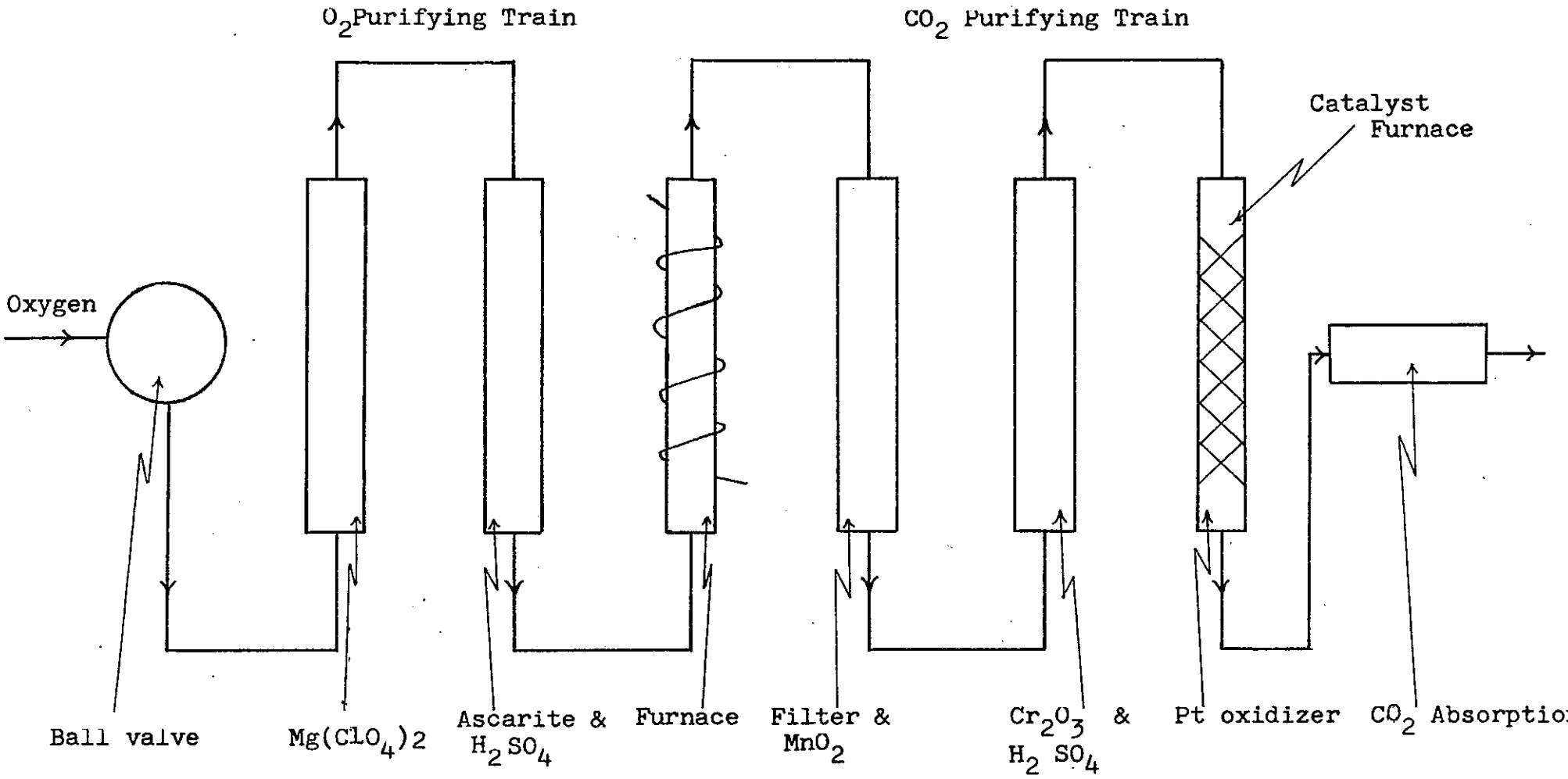


Figure 3.38: Schematic diagram of combustion train for determining total carbon in soil. (After Hesse, 1971).

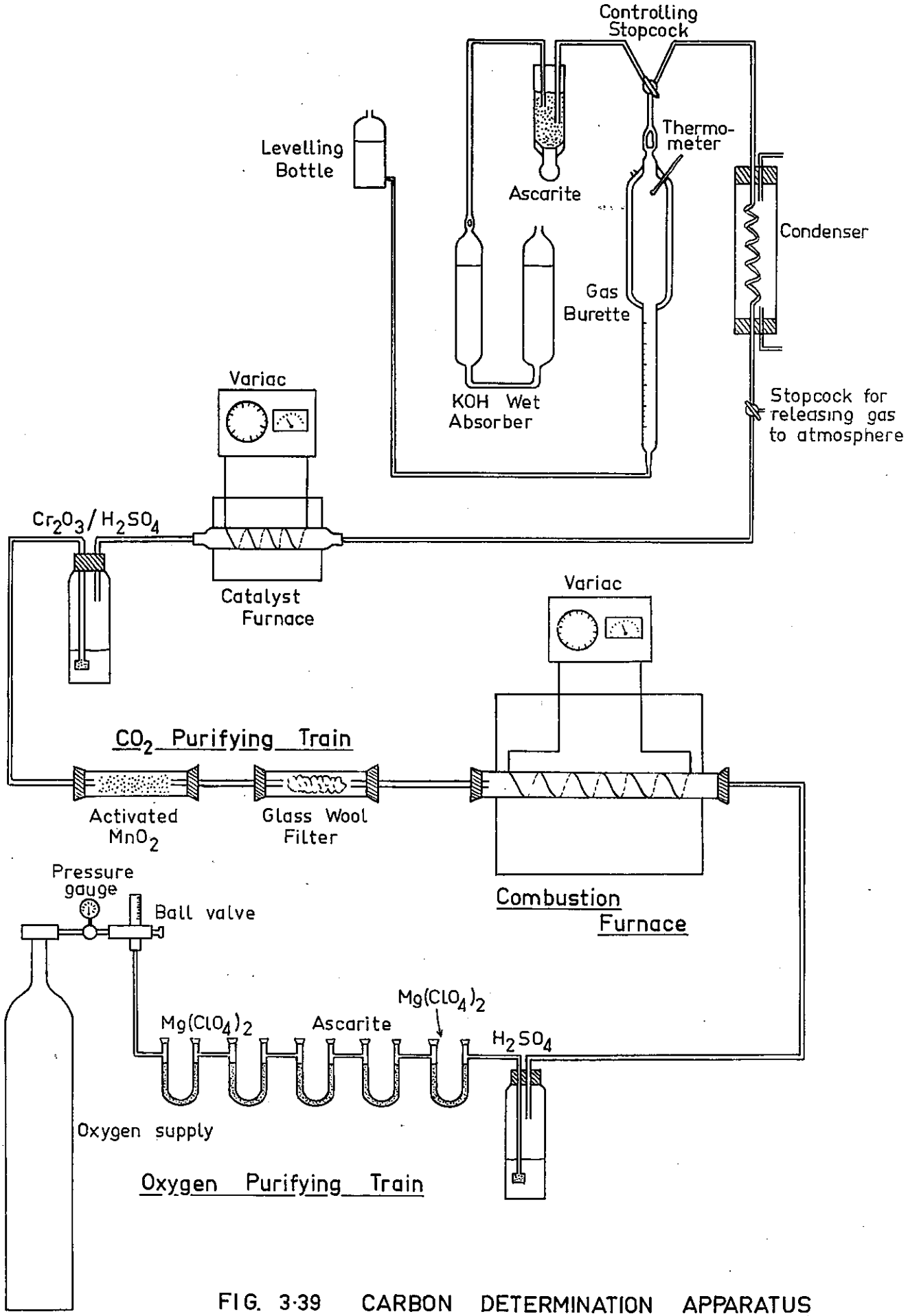


FIG. 3·39 CARBON DETERMINATION APPARATUS

in any significant quantities. The principle of total carbon analysis is to convert the carbon completely into carbon dioxide, which is then determined volumetrically.

The method used for dry combustion was the "Ströhlein method" in which the entire carbon content of the sample is burnt at 1200°C to carbon dioxide in a flow of pure oxygen. The amount of carbon dioxide produced is measured volumetrically by comparing the initial displacement of the liquid in the burette with the final displacement. The difference is read off the scale as percentage of total carbon. Between the initial and final readings, the gas is passed back and forth through "ascarite" which absorbs any carbon dioxide present.

The schematic diagram and photographs of the combustion train illustrate the set up of the apparatus. (Figures 3.38 to 3.42). The oxygen supply is one of industrial compressed oxygen which has a pressure gauge and ball valve. This regulates the pressure of the escaping oxygen and permits a steady flow of oxygen through the train. Since the oxygen was not analytically pure, an oxygen purifying train was used (Figure 3.40). The train consisted of magnesium perchlorate which dried the oxygen, "ascarite" for the removal of carbon dioxide and concentrated sulphuric acid, used to remove ammonia and hydrocarbons.

The carbon dioxide purifying train (Figure 3.41), which follows the furnace "cleans" the gas before it reaches the volumetric apparatus. The glass wool filter

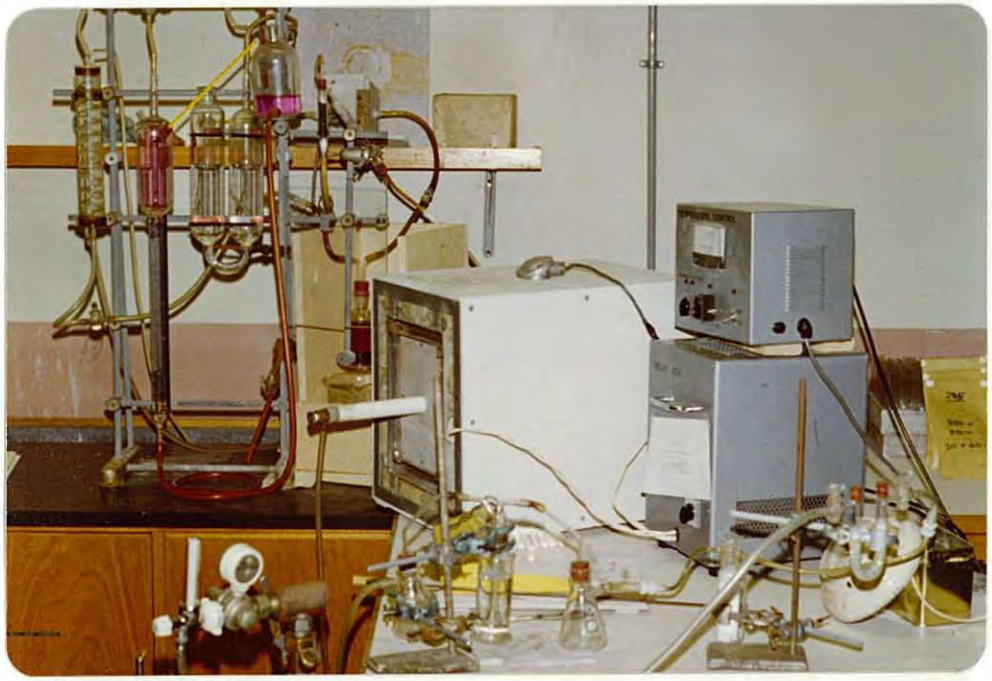


Figure: 3.40 Ströhlein Apparatus. Oxygen purification train in the fore-ground, with furnace and relay box infront of volumetric burettes.

tube removes finely divided metallic oxides. The activated manganese dioxide removes nitrogen and sulphur oxides and halogen gases before they poison the catalyst in the low temperature furnace. Sulphur dioxide and water vapour are removed by the concentrated sulphuric acid/chromic acid scrubber.

Should any carbon monoxide be present in the gas, it has to be converted to carbon dioxide. This is done in a low temperature catalyst furnace. (Figure 3.41). The catalyst used is platinum which oxidizes the monoxide to the dioxide.

The purified gas is cooled to a constant temperature by a condenser, before it passes into the volumetric apparatus. (Figure 3.42).

When analysing organic-rich soils it is advisable to use only very small amounts (0.1g) mixed with fired aluminium oxide. If this is done, the rate of oxidation of the carbon will be decreased, and no violent explosions or "blow-backs" will occur within the system.

The length of combustion time varies with sample type and the form of carbon being oxidized. In order to determine the optimum combustion time for the soil samples, one sample was reanalysed a number of times. A range of combustion times were used, varying from one to ten minutes. The analytical results (%C), for that sample were plotted against combustion time (Figure 3.43). This showed a rapid rise in measured carbon for combustion times between 1 and 2.5 minutes. For combustion times longer than five minutes there was a steady decline in

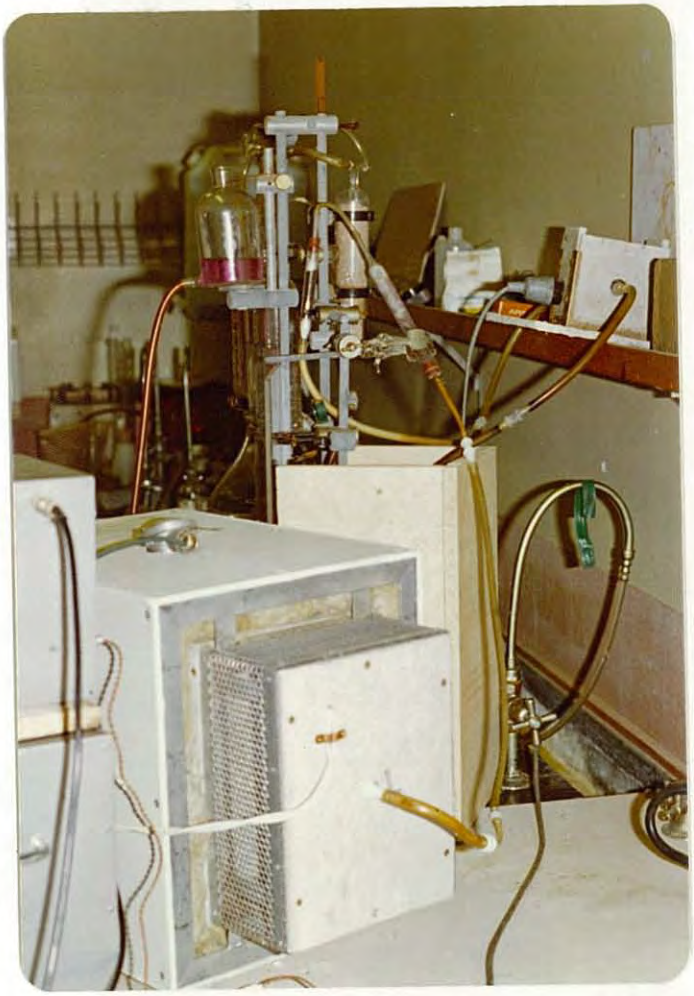


Figure: 3.41 Back of high temperature furnace showing the carbon dioxide purification train leading up to the low temperature catalyst furnace.

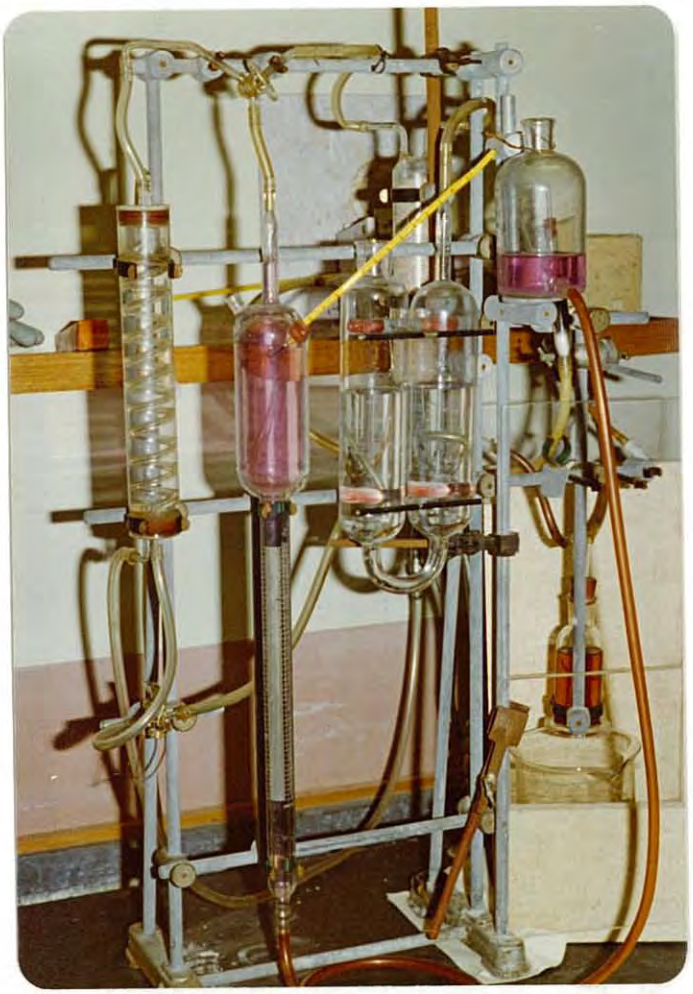
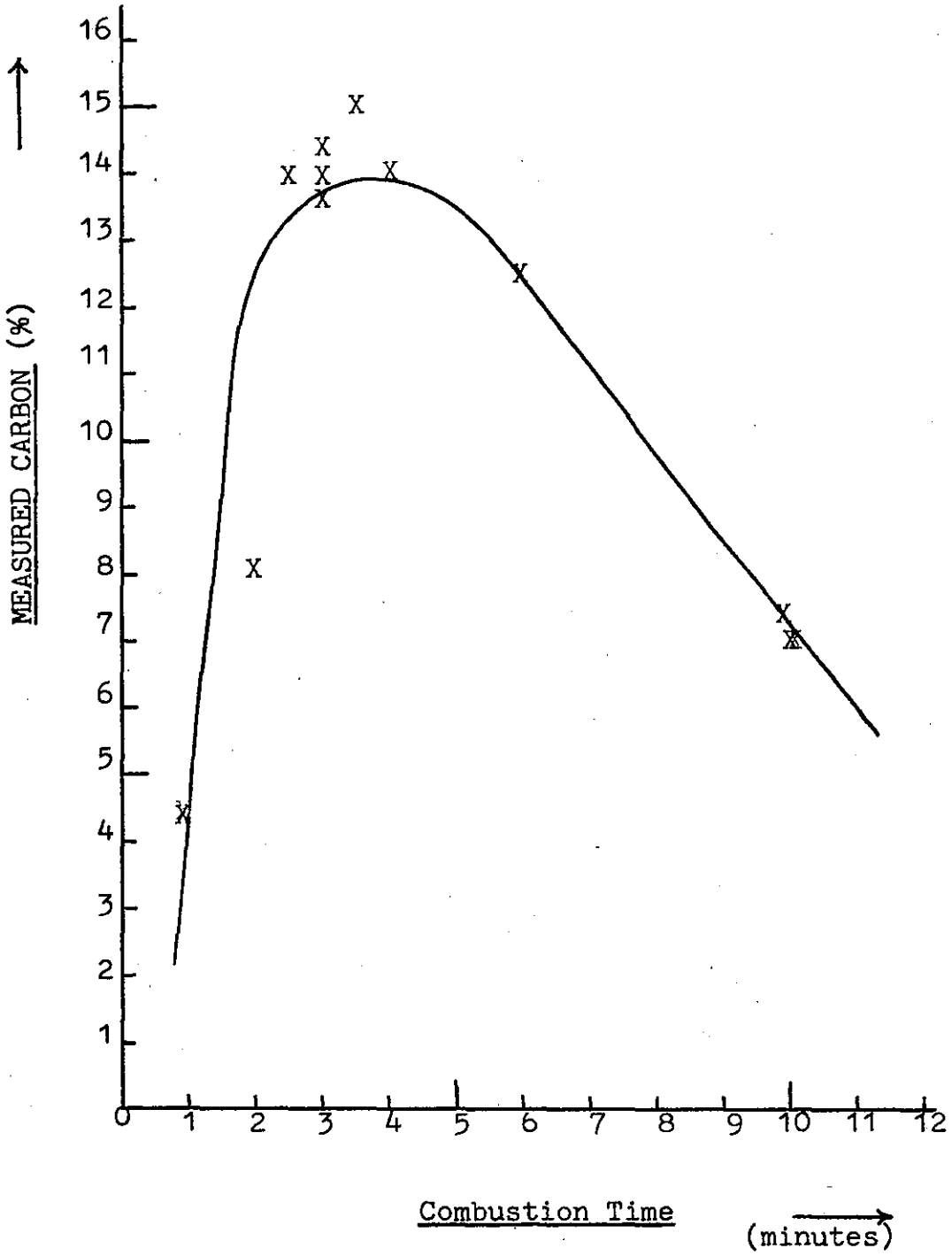


Figure: 3.42 Volumetric Burette apparatus with condenser (left), burette (centre) and leveling bottle (right). The Cr_2O_3 / H_2SO_4 conc. scrubber is situated behind its saftey screen at the bottom right.

the amount of measured carbon. Hence the optimum time for combustion of the soil samples was determined to be 3 minutes. For shorter combustion times, not all the carbon had been oxidized. The steady decline in measured carbon for combustion times longer than five minutes, could be a reflection of diffusion, or minor leaking of the carbon dioxide to the atmosphere.

Once the intricacies of this method are mastered, the determination of total carbon by dry combustion, can be a rapid, precise and reproduceable method of analysis.

FIGURE 3.43 CARBON YIELD (%)~COMBUSTION TIME
(for sample 246)



Sample Preparation (a) 0.1 gm sample No. 246
(b) Mixed with two times own weight Al_2O_3 and covered with thin layer of Al_2O_3.

3.5 HORIZONTAL DISTRIBUTION OF TRACE ELEMENTS.

(i) E.Z. Company's Previous Work.

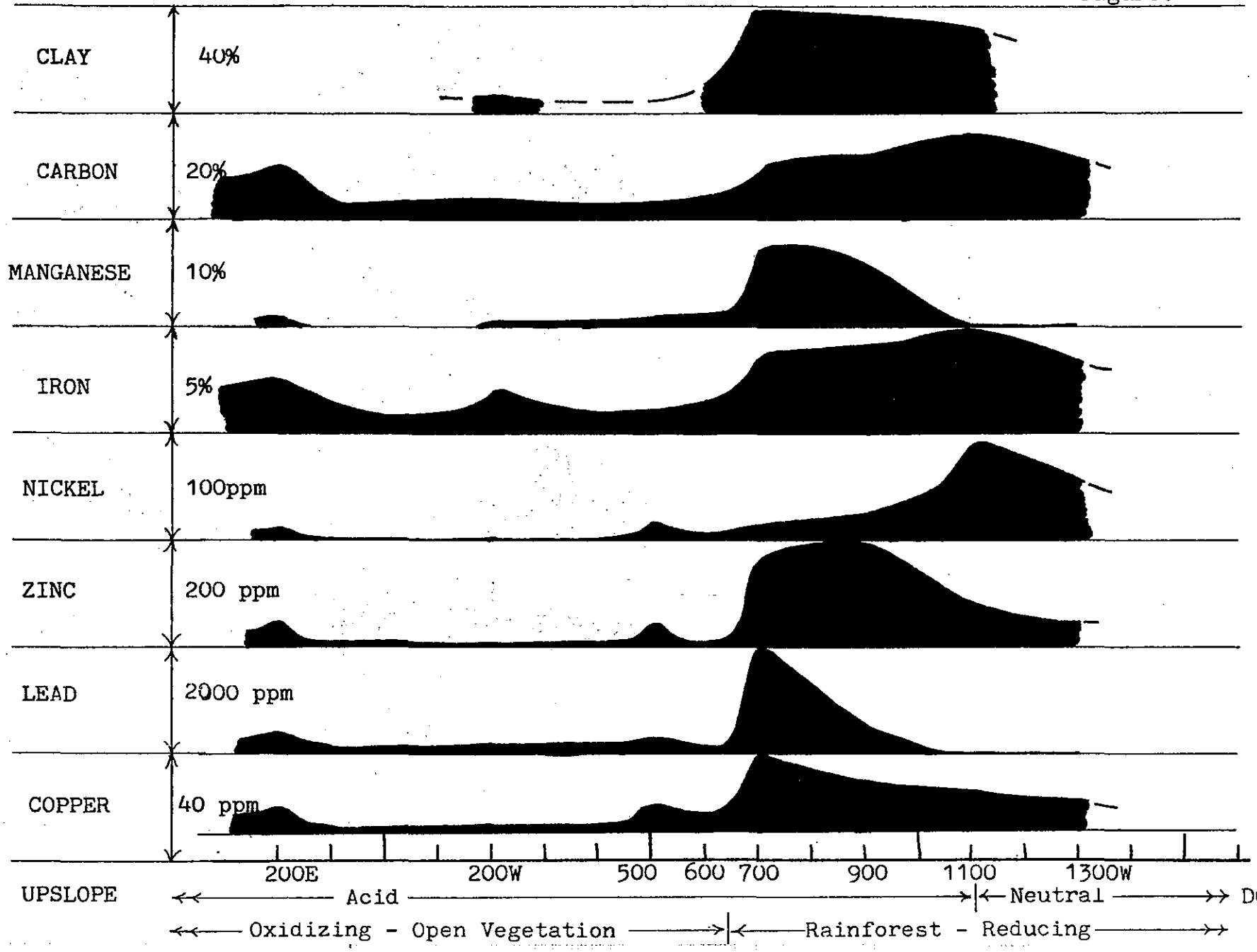
Pedogeochemical sampling by the Company had delineated a major lead geochemical anomaly in the West Hercules Area (Figure 3.1). This geochemical anomaly was partially supported by a gradient array induced polarisation survey. Two holes (WHP 192 and WHP 193), were drilled to further investigate the area. The drilling results suggested that pyrite mineralization was sufficiently intense within the black shales to produce the I.P. anomaly. However, no significant mineralization was intercepted by the drill holes.

Within the project area, near the end of the drill access track, mineralization is contained in widely scattered 10-30 mm ellipsoidal concentrations and small veins. This occurs with-in siliceous, fine grained, devitrified tuff. It has been suggested that this mineralization has been formed by the replacement of carbonate "augen" (Stone, 1975).

(ii) Mobilities and Fixation of Trace Elements.

As groundwater rich in trace elements, percolates down slope, different elements will be fixed or precipitated by different conditions. This will produce a "chromatogram"-type dispersion pattern. (Figure 3.4). In the West Hercules Area, copper, lead and zinc appear to be fixed by similar conditions as do nickel, iron and manganese.

Concentration "CHROMATOGRAM" OF ELEMENTS DOWN 40ON Figure: 3.44



(a) Copper, Lead and Zinc.

These elements are immobilized by neutral, reducing conditions (Levinson, 1974). Figure 3.4 shows the "co-fixation" of these three elements down line 400N. To the east (upslope), the weathering of sulphides from the Hercules East Rocks develops an acidic, oxidizing environment in which copper, lead and zinc are mobilized. At 650W, the vegetation changes from open bushy shrubs on shallow soils to close, thick rainforest on deep soils. This signals the onset of a change in Eh, conditions, from an oxidizing environment to a reducing one. The sudden increase in organic carbon in the soils is (Figures 3.4-5-6), brought about by the increase in decaying organic matter. This will result in a sudden lowering of Eh, sufficient to drastically reduce the mobilities of copper, lead and zinc. Evidence for reducing conditions in the rainforest is provided by gley patches in the soils. Krauskopf (1967) has found that carbon-rich environments commonly have Eh values between -0.1 to -0.4 for a pH range of pH 4-7. The organic material can also increase the pH of the soil to around pH7 (Krauskopf, 1967). This increase in pH would reduce the mobilities of copper, lead and zinc further.

Copper is reported to be strongly sorbed on clays and rapidly fixed by organic matter (Hesse, 1971). The increase in pH would enhance the sorbtion of copper and possibly lead and zinc, on the clays (Levinson, 1974). It is of interest to note that the clay content of the

Figure: 3.45 PERCENTAGE ORGANIC CARBON IN SOILS

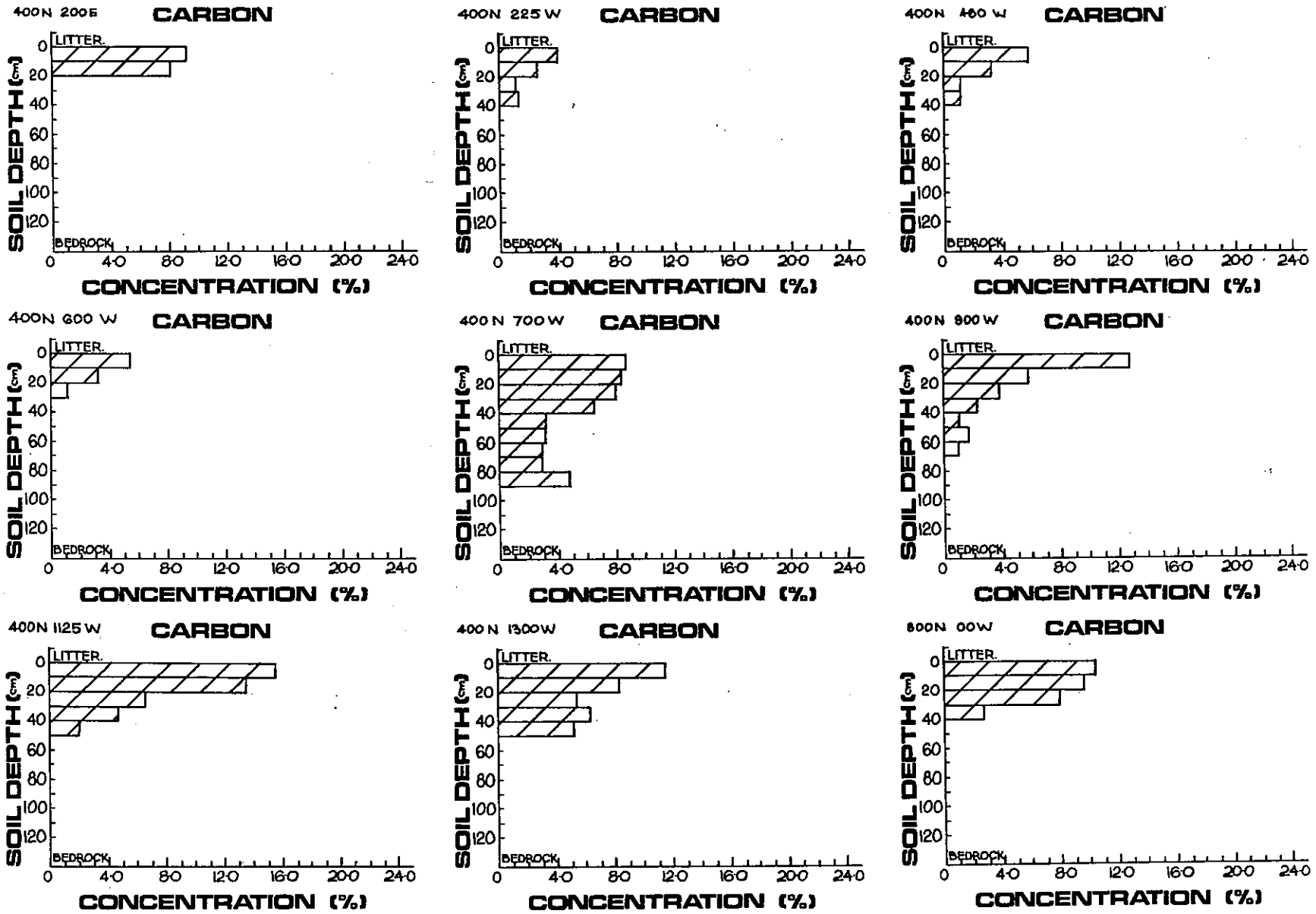
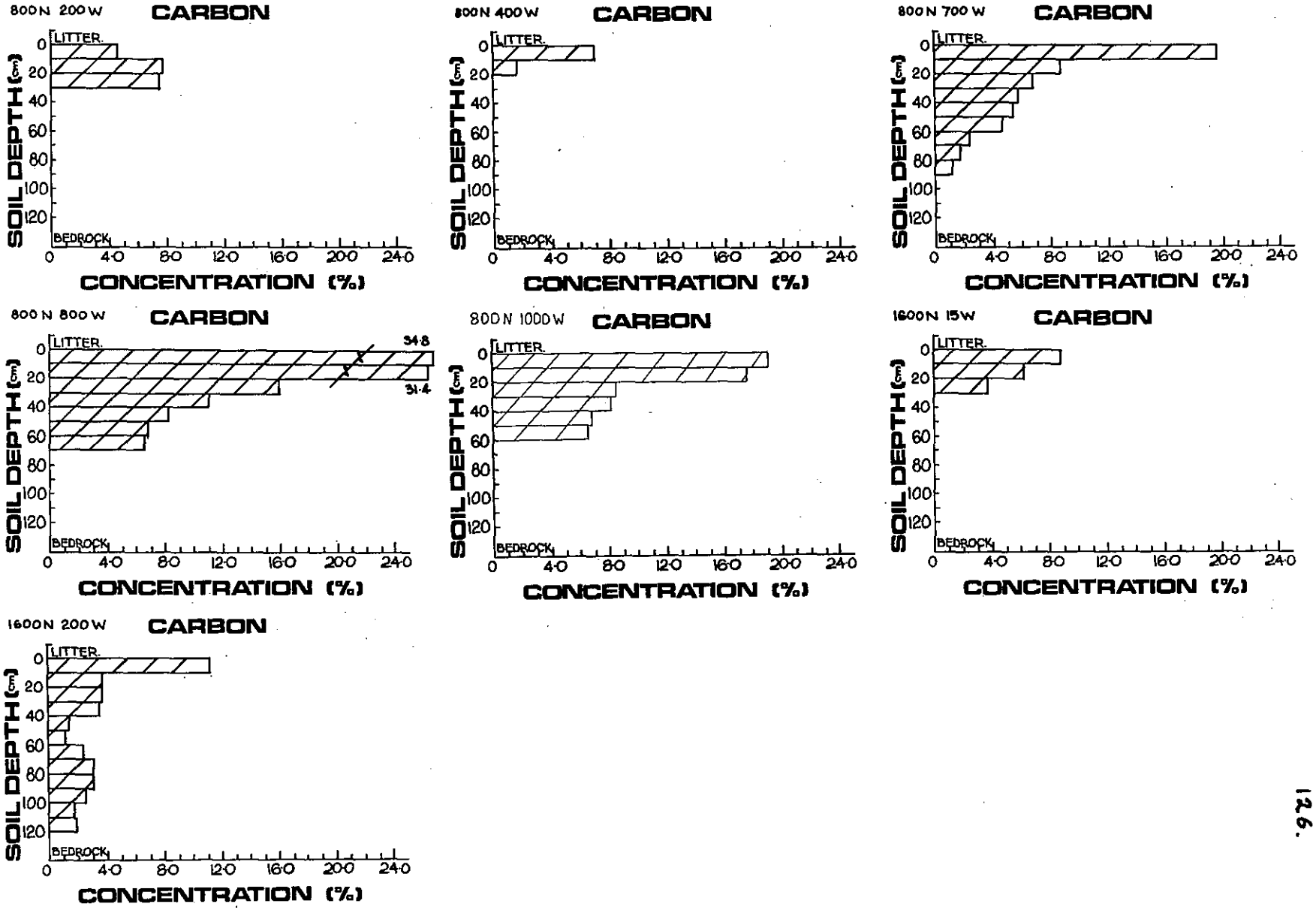


Figure: 3.46 PERCENTAGE ORGANIC CARBON IN SOILS



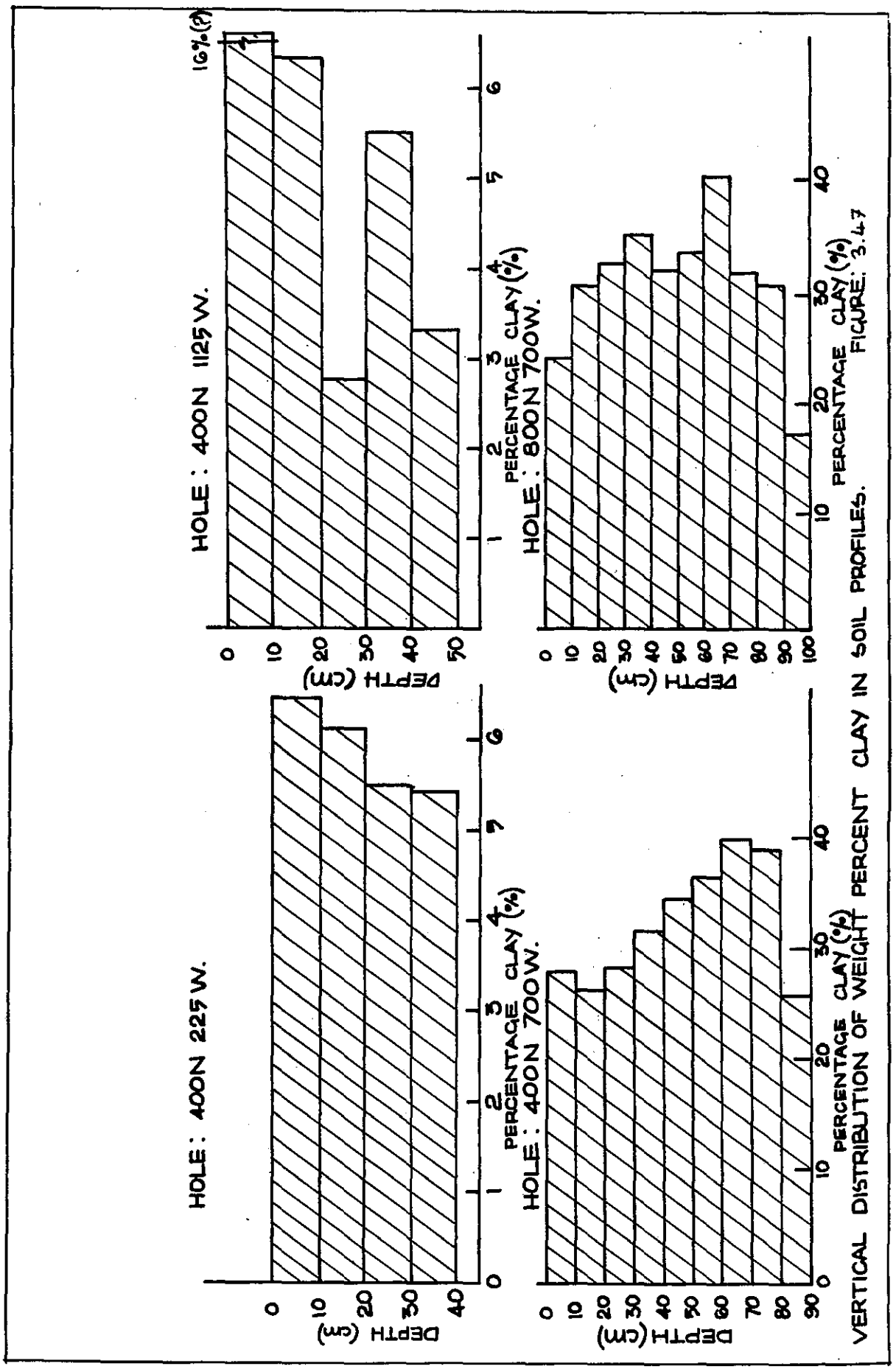
soils increases from 6% (off the anomaly) to 40% by weight over the anomaly (Figure 3.47). This increase in clay content is brought about by two processes, downslope migration of soil and increased weathering of the sericite tuff. Both processes are related to the fact that at 400N 650W and 800N 550W there is a break-in-slope which can be attributed to the change in rock type from white siliceous tuff to green sericite tuff. (Stone, 1975). The green sericite tuff weathers faster, produces more clay and results in the break-in-slope. (C. Eastoe, pers. comm.).

Another "barrier" to the copper, lead and zinc would be the increase in iron and manganese concentrations at the start of the soil anomaly. The sequential soil analysis was designed to assess the effect of different soil phases (including iron and manganese) in fixing the trace-elements. This will be discussed in a later chapter.

A glance at the parent rock trace element values for 400N will show that mineralization of parent rock cannot be invoked to explain the presence of the soil anomaly down 400N . The only interesting peak in elemental values occurs at 400N 1125W, below the geochemical anomaly!

(b) Nickel, Iron and Manganese.

These three elements share the property of being very immobile under neutral conditions. Iron and manganese can also be immobile under oxidizing conditions provided the pH is high. (Krauskopf, 1967). However, on



VERTICAL DISTRIBUTION OF WEIGHT PERCENT CLAY IN SOIL PROFILES.
FIGURE: 3.47

the upper slopes, while the environment is oxidizing, it is also acidic. Hence, under these conditions the nickel, iron and manganese would remain mobile until the pH was raised above pH 5.5 (Hesse, 1971). The increased accumulation of organic matter in the soils past 400N 650W and 500N 550W would start to raise the pH. This would be a more gradual change than that of the Eh. The pH would increase from pH 4.5 (Gatehouse, 1973) to a maximum of pH7, deeper down in the rainforest. Thus the concentration of nickel, iron and manganese could be expected to rise from 400N 650W, to a peak further down the line. Figure 3.44 illustrates this.

A consideration of the parent rock elemental values suggests that a contributing factor to the peak in iron and manganese values at 1125W is the parent rock (Figure2.30). This increased concentration of iron in the parent rock is reflected in the soil.

The poorly drained soils of the rainforest were coloured greenish-grey to grey by Fe(II) compounds, providing evidence for reducing conditions. While iron is mobile under reducing conditions, it can only remain in solution as a suspension or complexes in the pH range of 5 to 8. (Hesse, 1971). An important factor in the mobilization of iron is the formation of organic complexes or chelates. Leachates of leaves and forest litter are very active in the mobilization of iron. It is this complexing that would produce the mobility of iron (under neutral conditions) which results

in the rather wide "dispersion trial" of iron. There is however, a limiting factor to the mobilization or iron by organic complexing. The reducing conditions produce Fe(II) which is less strongly complexed than Fe(III). Hesse, 1971).

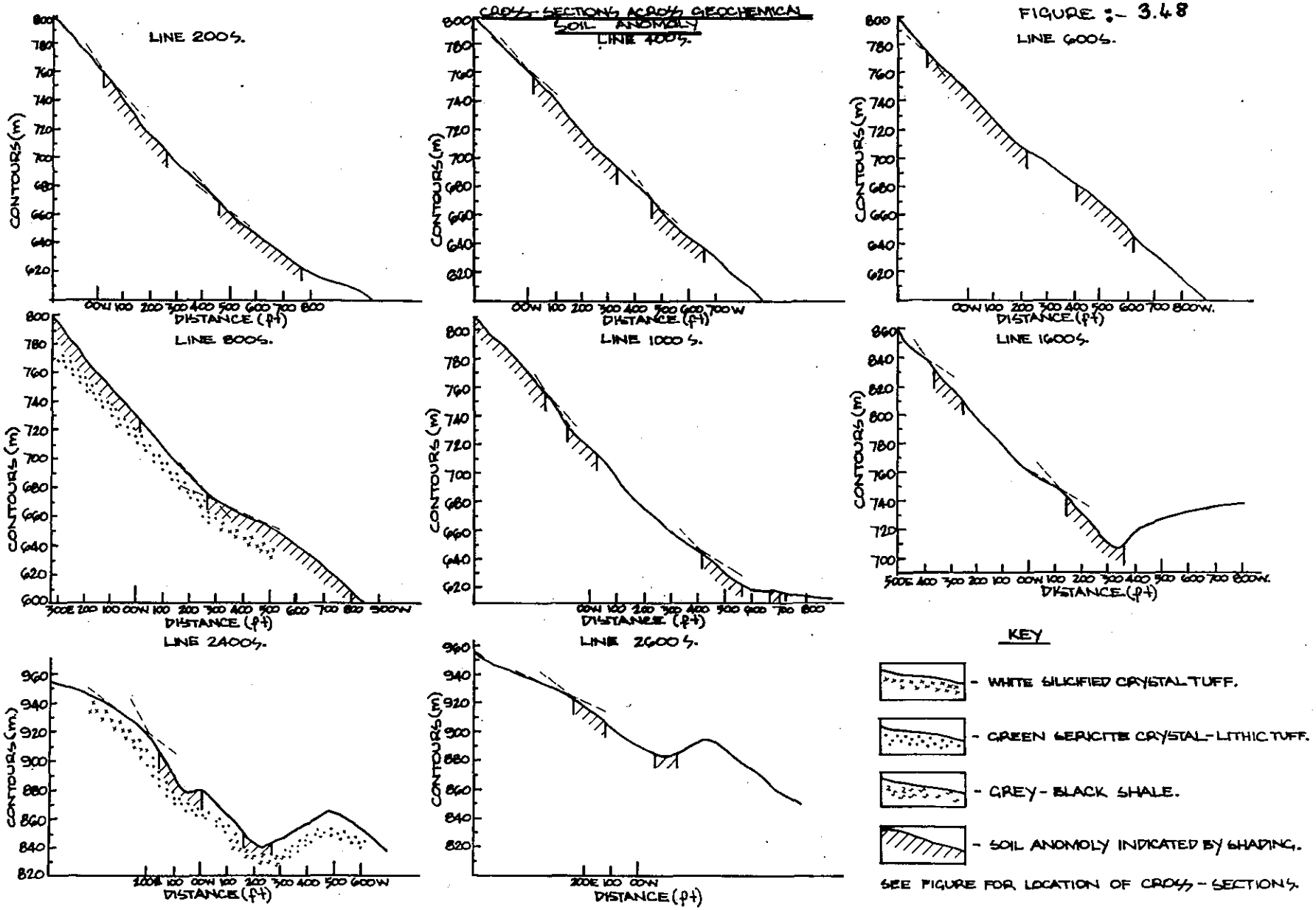
(iii) Topographical Analysis (Figures 3.48 to 3.50).

A series of topographic cross-sections were drawn from a contour map, (Figure 3.1) and the lead pedogeochemical anomalies were plotted for each line. Where the parent rock type was known, it was added to the cross-section. The cross-section was drawn down seventeen lines, at right angles to the anomaly, and 200ft. apart. It should be noted that due to the insensitivity of this method of analysis, caused by variation in vegetation heights and contour coarseness, only prominent changes in slope would be displayed.

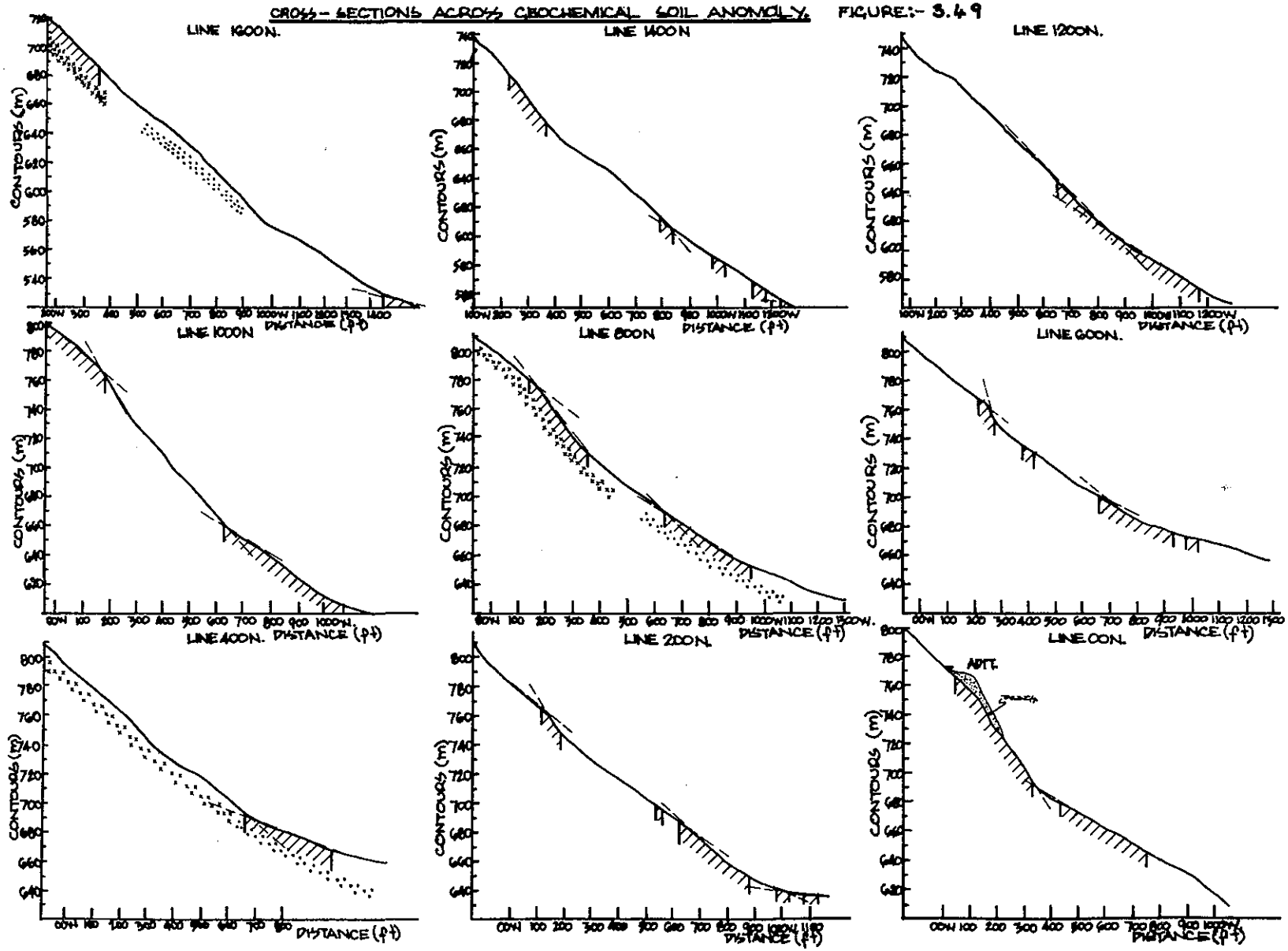
The major lead pedogeochemical anomaly always occurs downslope of the other minor anomalies, its lowest limit being the stream bed at the bottom of the valley floor. It never crosses this stream bed or topographic low onto the opposite valley sides. Where the anomaly reaches the stream bed, it is distributed assymetrically about the topographic low, skewed towards the upslope Hercules Host Rocks (e.g. Lines 1600S and 2400S). These observations suggest that the pedogeochemical anomaly experiences a considerable amount of topographic control.

Further to these observations, the major anomaly occurs at a distinct break-in-slope in fifteen out of the seventeen cross-sections. The break-in-slope is indicated

FIGURE :- 3.48


CROSS-SECTIONS ACROSS GEOCHEMICAL SOIL ANOMOLY
LINE 200S.
LINE 400S.
LINE 600S.
LINE 800S.
LINE 1000S.
LINE 1600S.
LINE 2400S.
LINE 2600S.
CONTOURS (m)
DISTANCE (ft)
KEY
- WHITE SILICIFIED CRYSTAL TUFF.
- GREEN SERICITE CRYSTAL-LITHIC TUFF.
- GREY-BLACK SHALE.
- SOIL ANOMOLY INDICATED BY SHADING.
SEE FIGURE FOR LOCATION OF CROSS-SECTIONS.

CROSS-SECTIONS ACROSS GEOCHEMICAL SOIL ANOMOLY. FIGURE:- 3.49



on the figures by the intersection of dashed lines. The two locations in which there is no distinct slope-control of the anomaly are from 400S 500W to 600S 500W from 600N 700W to 800N 700W. Hence these two locations could be likely candidates for some form of bed rock mineralization.

The upper most anomaly would have been produced by contamination from the Hercules Open Cut Mine (C.Stone pers. comm.)

Both these cross-sections and a study of aerial photographs indicate that the adit (00N 00W) and its tailings have produced the associated secondary dispersion anomaly.

The two other small anomalies that occur upslope of the major anomaly could be related to mineralization in the bed rock. These anomalies are situated at 1600N 200W and 1000N 00W and occur in the region of previously discussed, minor mineralization by replacement of carbonate "augen".

A topographic cross-section was drawn down the length of the major anomaly, crossing the previously drawn sections (Figure 3.50). It can be seen that the anomaly occurs down a steep gradient from 2600S 200E to 1000S 450W and from 600N 750W to 1600N 1500W. Between these two sections, there occur two small hills, one with a peak at 600S 500W, the other at 600N 750W. This re-enforces the previous suggestion that some form of bed-rock mineralization occurs at 600S 500W and 600N 750W. If this were the case, the central section of this anomaly (i.e. 800S 450W to 400N 700W) could be caused by downslope dispersion from these two mineralized locations.

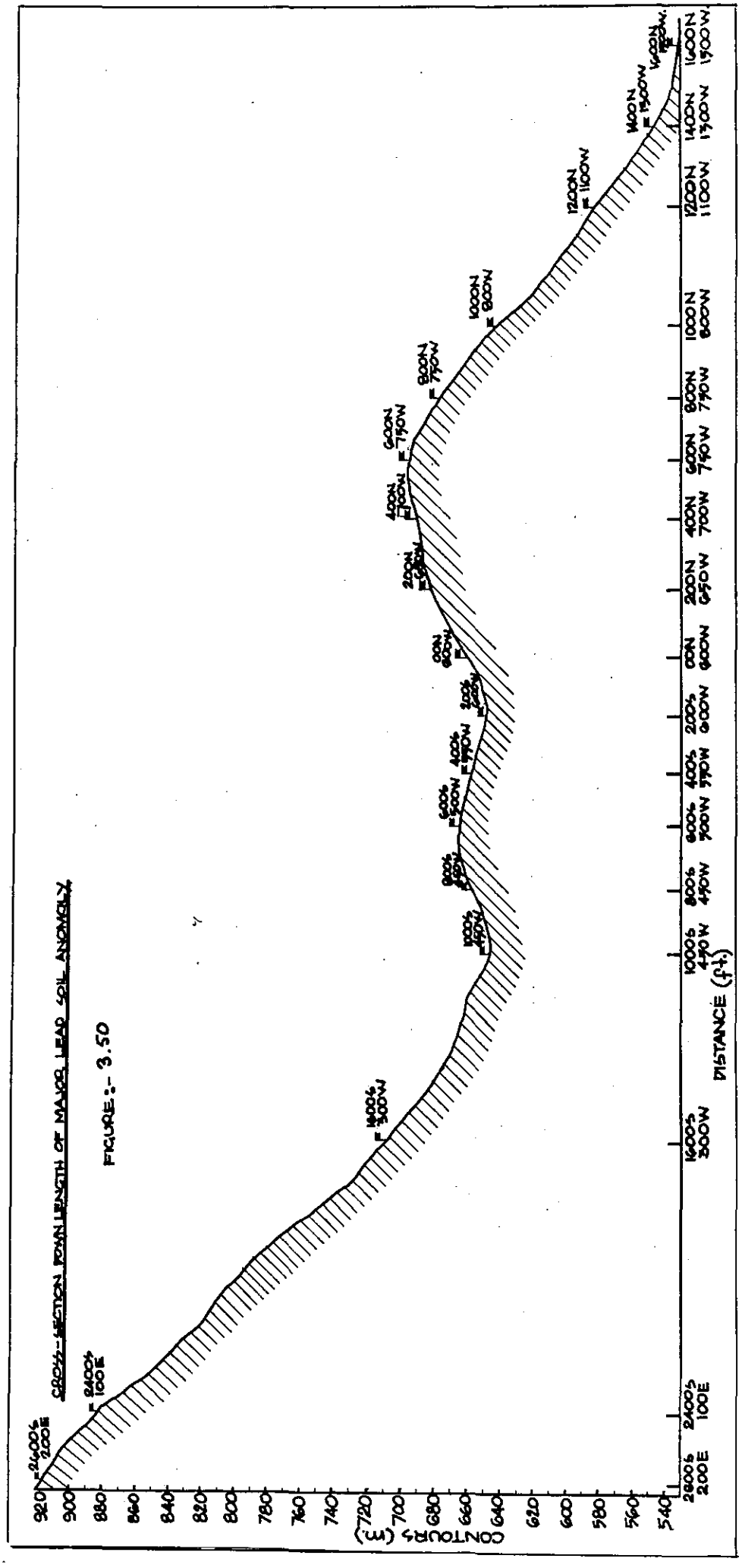

CROSS-SECTION ROWLENGTH OF MAJOR LEAD SOIL ANOMALY
CONTOURS (ft.)
DISTANCE (ft.)
24005 200E
24005 100E
14005 300W
10005 400W
8005 500W
6005 600W
4005 700W
2005 800W
0N 900W
200N 1000W
400N 1100W
600N 1200W
800N 1300W
1000N 1400W
1200N 1500W
1400N 1600W
1600N 1700W

FIGURE:- 3.50

(iv) Summary.

Several different conditions have acted as "barriers" to the mobile trace elements. These have been rendered immobile by adsorption, scavengers and changes in the Eh, pH environments. The following are significant controlling factors of the anomaly.

(a) Parent Rock.

The parent rock could exert two types of control, one based on its resistance to weathering, the other on its concentration of metals. In the project area, the latter control could only be of importance in two possible locations, with the possible exception of generally influencing the concentration of iron and manganese in soils. The former control is all-important as the change in rock type from siliceous tuff to sericite tuff results in increased weathering of parent rock, producing increased clay content, a break-in-slope and subsequently deeper soils covered in rainforest, which provided greater amounts of organic carbon for the soils.

(b) Eh and pH Environment.

The soil environment changes down 400N and 800N from an oxidizing, acidic environment to a reducing, neutral one. This change in environment acts as a "barrier" for the various trace elements as they reach their optimum conditions for fixation. The change is essentially caused by the sudden increase in organic carbon content in the soils. A secondary effect of this control is the increase in scavengers of copper, lead and zinc. This effect is investigated in a following section dealing with the sequential analysis of soils. (Perel'man, 1967)

(c) Topography

The indications of the topographical analysis were that the major pedogeochemical anomaly is a seepage or hydromorphic anomaly controlled by the topography. The two possible exceptions to the topographic control were the locations 400S 500W to 600S 500W and 600N 700W to 800N 700W, which could contain mineralization.

The small anomalies at 1600N 200W and 1000N 00W could also be directly related to minor mineralization in the bed rock. However, drill hole results (WHP 193) indicated that the mineralization at 1000N 00W was insignificant.

3.6 VERTICAL DISTRIBUTION OF TRACE ELEMENTS.

Each of the thirty holes dug were sampled every ten centimetres and analysed for Cu, Pb, Zn, Ni, Fe and Mn (Appendix D.3). Graphs were then drawn for each element down each hole (Figures 3.51 to 3.70, page 144). Soil depth was expressed down the vertical axis and element concentration along the horizontal axis. This data was used to determine relative element mobility, which elements "followed" which and which depth would be the best for pedogeochemical sampling.

(i) Vertical Variation.

The concentration of each element varied with depth, different elements having different trends. Some soils were distinct "compound" soils (e.g. 800S 400W and 1600N 200W). That is, they were composed of several soils, one on top of the other. Distinct "A" and "B" horizons were evident for up to four separate soils, the youngest on the top. This "compound" nature of the soils underlined the importance of downslope transportation to the depth and maturity of the soil profile.

(a) Copper.

The litter in each profile always contained more copper than did the soil. This was due to copper's affinity for organic material, as reflected by the higher values of copper in the upper ten centimetres of the profile. Once into the "A"-horizon, this element was present only in very low concentrations. Then, the amount of copper increased with depth to the base. The exceptions were the "compound" soils in which the copper

increased to a peak at 40-50 cm.

Often the last sample in the "C" horizon,was depleated in copper. In profiles where there was mimimal copper, the vertical distribution was uniform.

In those profiles which had been analysed for clay, the vertical copper distribution very closely followed the vertical clay distribution, (with the exception of one hole below the anomaly which did not contain much copper). This is further evidence for the sorbtion of copper by clays.

(b) Lead.

The "compound" soils are very clearly reflected by the lead values down the profile. This illustrates the relative immobility of lead once it has been fixed.

In general lead concentrations tend to peak about two-thirds the way down the profile, often at 60-70 cm. Off the anomaly, lead values show no vertical variation, bar a slight decrease to the base. The litter is always high in lead and often reflects the soil concentrations.

The anomalous values for lead always occur in deep, mature holes (deeper than 50 cm), except where the lead anomaly is upslope. In such cases, all the lead has been removed from the groundwater before it reaches that specific soil profile.

(c) Zinc.

In general when zinc is present, it increases towards the base of the soil profile, with the maximum

zinc occuring in the bottom sample. This re-enforces the suggestion that zinc is very mobile.

(d) Nickel.

Nickel too is very mobile and as such is generally leached out of the profile. Often the parent rock contains more nickel than does the soil, another indication of nickel's mobility. When it is present in soils, the nickel content increases towards the base of the profile and is depleated at the top.

(e) Iron.

Where water-logging of the soil is not a problem, concentration of iron increases with depth. However, water-logged soils display a bimodal distribution down the profile. One peak in iron concentration occurs near the top, the other near the base of the profile. The middle sections of the soil profile are depleated in iron.

When the soil descriptions are studied (Figures 3.3 to 3.32), it transpires that the middle sections are those that contain gley patches and arewater logged. Hence, under these reducing conditions, the iron is present as the mobile Fe(II) species, resulting in localized iron depleation. (pages 194 to 224, Data Volume)

The higher values of iron in the top of the profile occur above the zone of saturation, in a more oxidizing environment containing free oxygen. This results in the fixation of iron in its oxide form.

When iron rich solutions percolate through a

soil profile, they tend to precipitate iron at depth due to either an increase in pH or adsorption by clay minerals (Hesse, 1971). This mechanism accounts for the increasing iron concentration at depth.

It is also of interest to note that all the high values of iron occur in deep, mature soils.

(f) Manganese.

The most prominent characteristic that manganese displays is its very close "following" of all the iron trends. This can be attributed to two factors, either the mobility of manganese is effected by the same conditions as the mobility of iron, or the manganese is scavenged by the iron and incorporated in its chemical structure. The former factor holds and the latter factor will be discussed in a later section.

(ii) Element Associations.

The soil-concentrations of the elements were plotted against the lead-soil concentration for that sample. (Figure 2.34). These plots indicated that there was a distinct linear relationship between lead-manganese and lead-iron in the soils.

These relationships strongly suggest that the lead in the soils is scavenged by the iron and manganese oxides present.

The better controlled and more distinct trend of the manganese-lead indicates that the manganese oxides are the most active scavenging agents for the lead. As the trends for iron and manganese are similar, this suggests that these elements co-precipitate. The

sequential analysis technique was used to investigate such scavenging relationships more closely.

Copper, zinc and nickel have an inverse relationship with lead in the soils. This could suggest that they compete with lead for the available sorbtion sites on the various soil phases. The plots could be interpreted as having two distinct populations. Each population is concerned with a different soil phase or sorbtion locality. The population with the near vertical trend could describe a soil phase that sorbs copper, zinc or nickel in preference to lead (e.g. sorption on clays). The near horizontal population would then represent a soil phase that sorbs lead in preference to copper, zinc or nickel (e.g. Mn or Fe oxide scavengers).

(iii) Summary.

The relative vertical mobilities indicated by this study are Ni > Zn > Cu > Fe/Mn > Pb. Hence, nickel is the most mobile element down a soil profile and lead is the least mobile under identical conditions.

The data also showed a significant decrease in iron and manganese concentrations in reducing gley sections, where the iron was present as Fe(II) thus releasing the manganese.

When the vertical distributions of iron and manganese were compared for each hole, it was obvious that the manganese was "following" the iron very closely.

The optimum pedogeochemical sampling horizon for nickel, zinc, iron and manganese is the "B_3" horizon.

When sampling for manganese or iron, care has to be taken not to sample any gley horizons. The optimum depth for copper sampling appears to be 50 cm. or the "B_3" horizon. In order to obtain the highest lead values, it is best to sample about two-thirds the way down a soil profile, or at a depth of about 70 cm.

Figure: 3.51 ELEMENTAL CONCENTRATION DOWN SOIL PROFILES

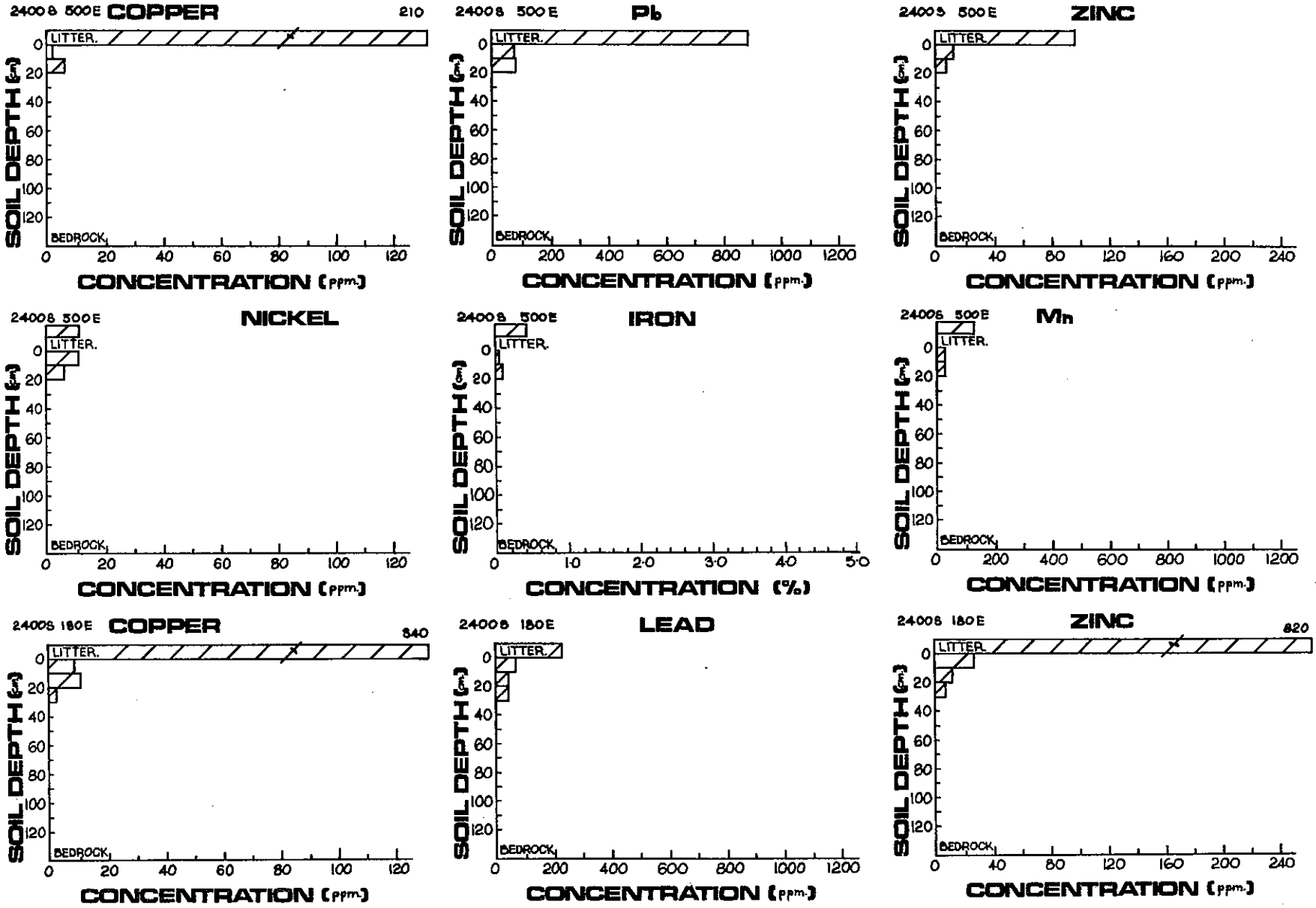


Figure: 3.52 ELEMENTAL CONCENTRATION DOWN SOIL PROFILES

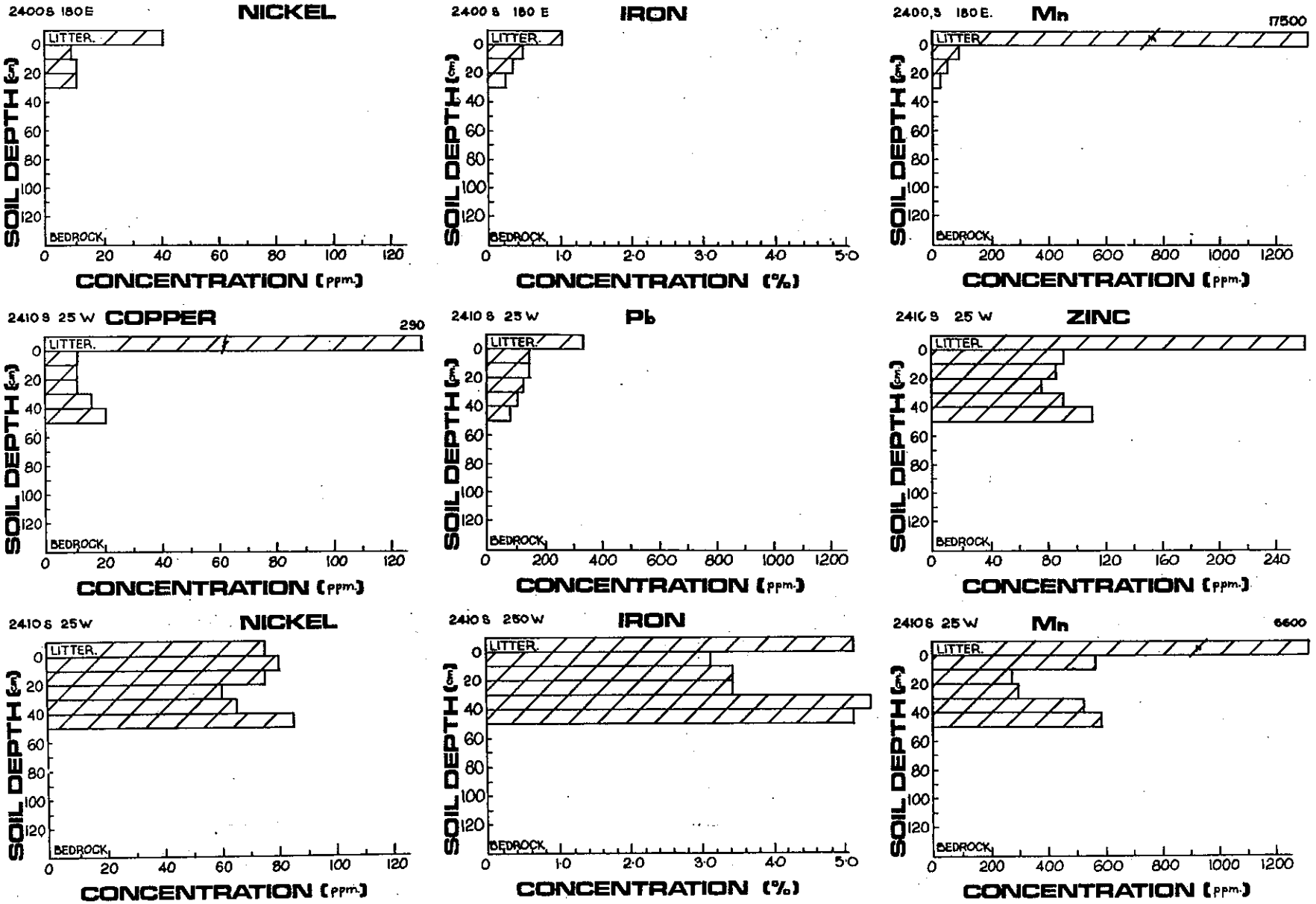


Figure: 3.53 ELEMENTAL CONCENTRATION DOWN SOIL PROFILES

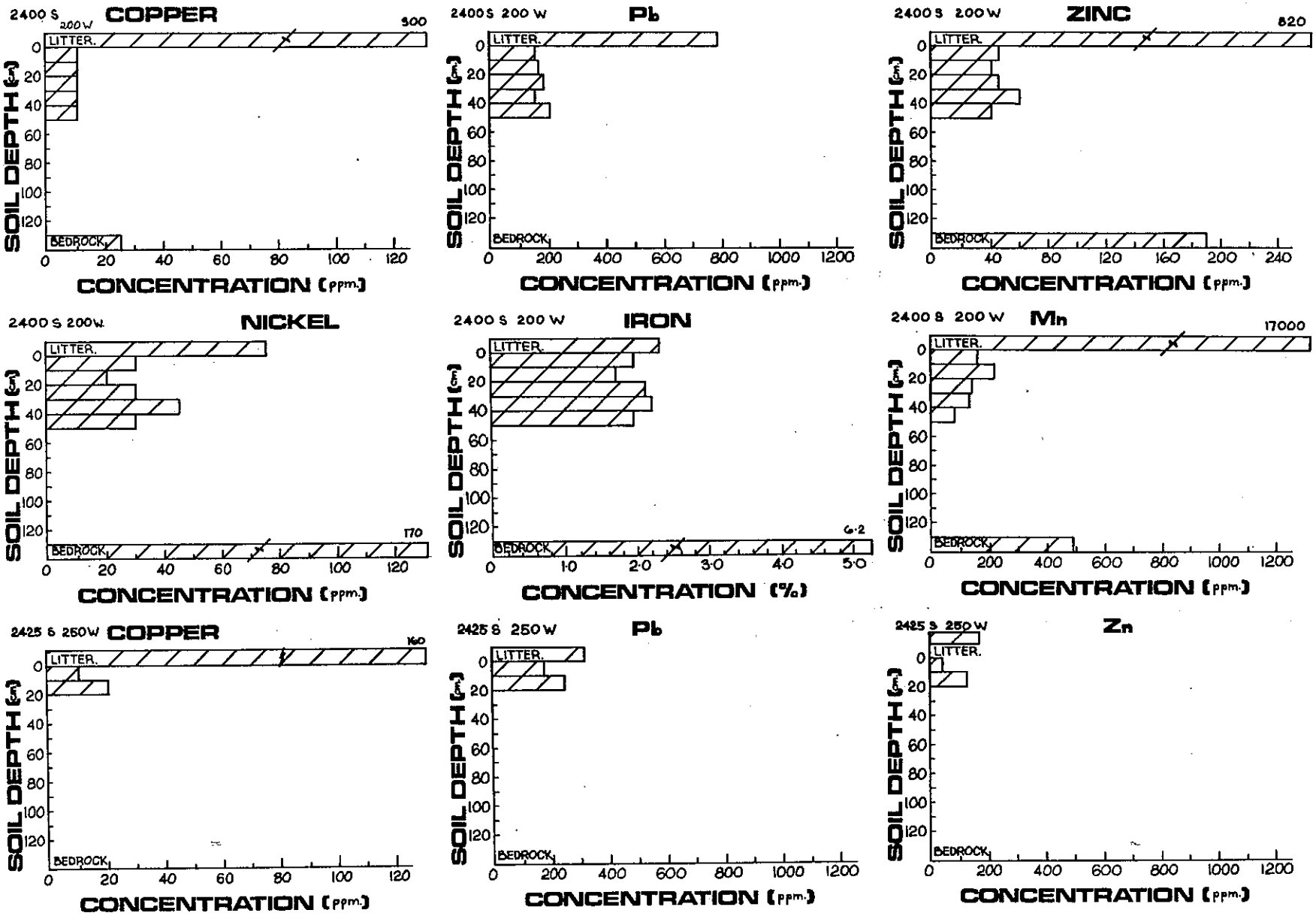


Figure: 3.54 ELEMENTAL CONCENTRATION DOWN SOIL PROFILES

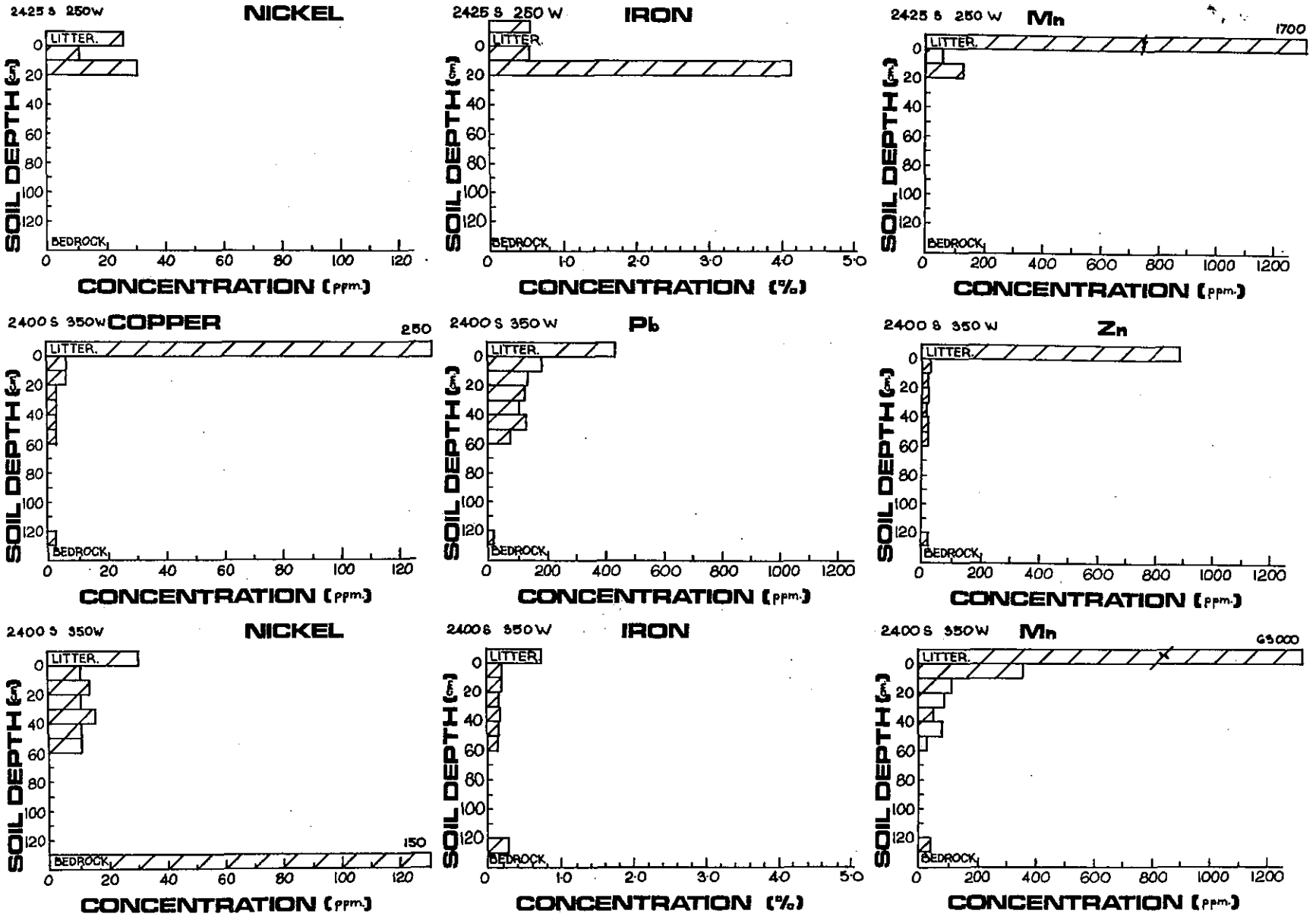


Figure: 3.55 ELEMENTAL CONCENTRATION DOWN SOIL PROFILES

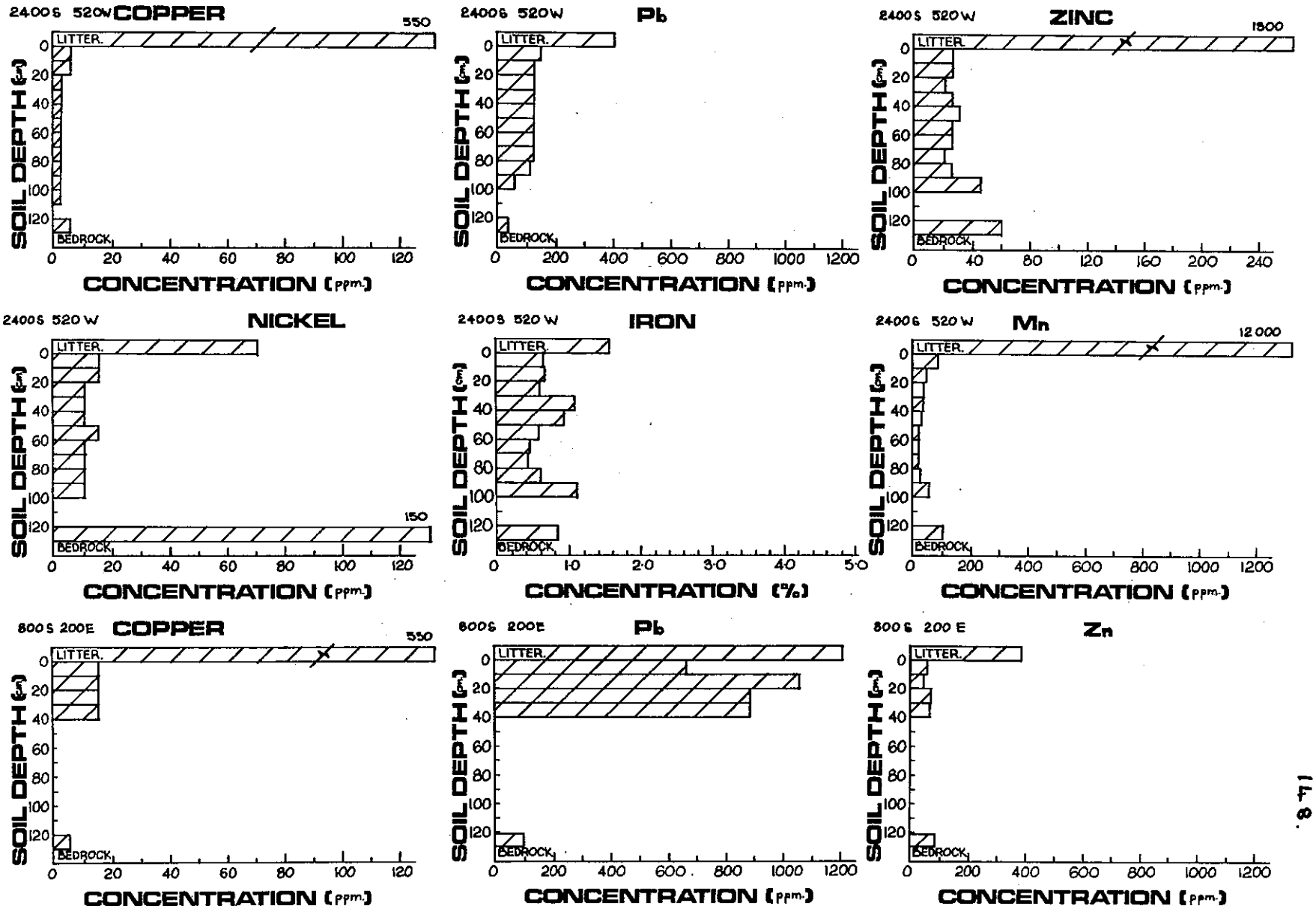


Figure: 3.56

ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

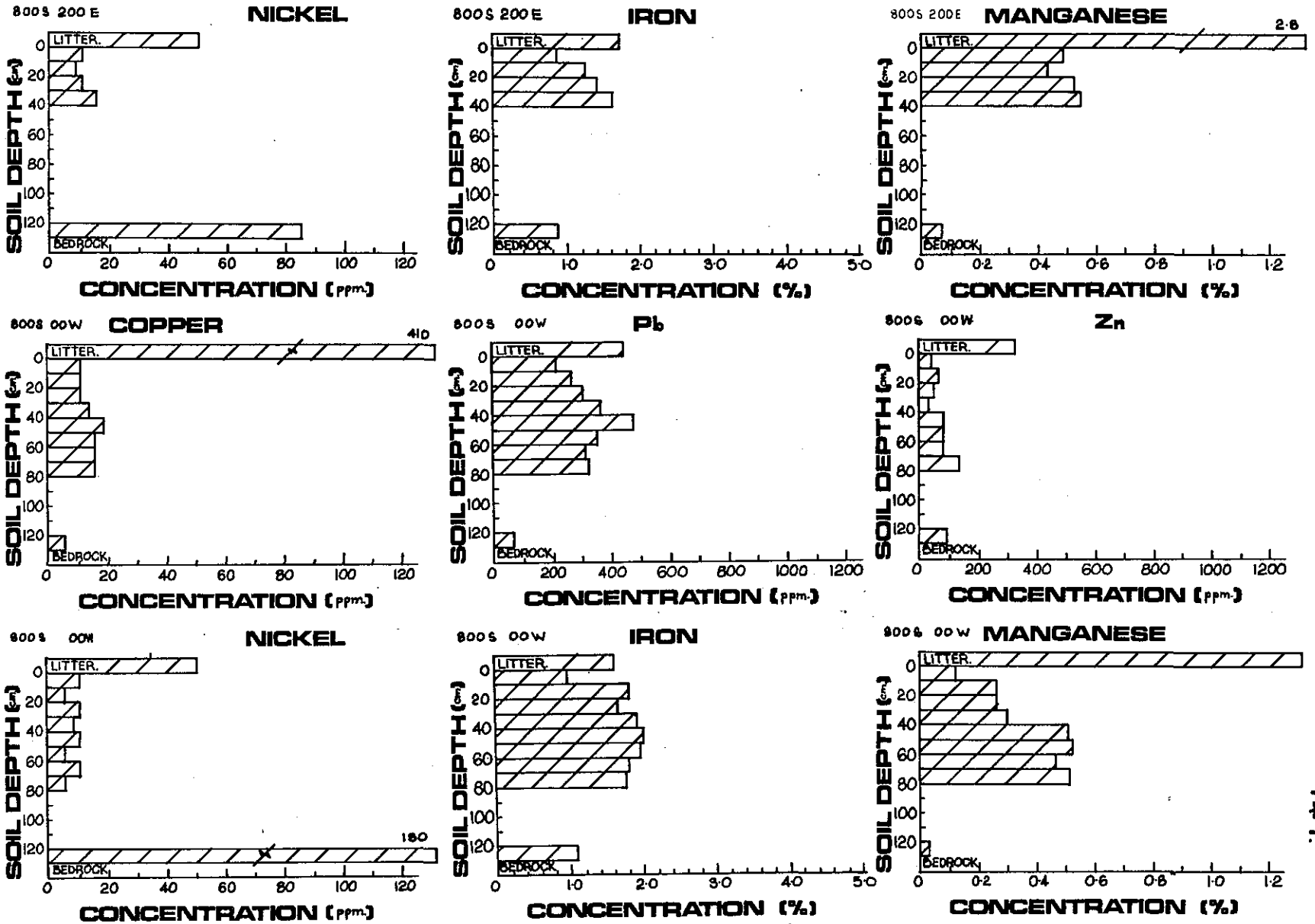


Figure: 3.57 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

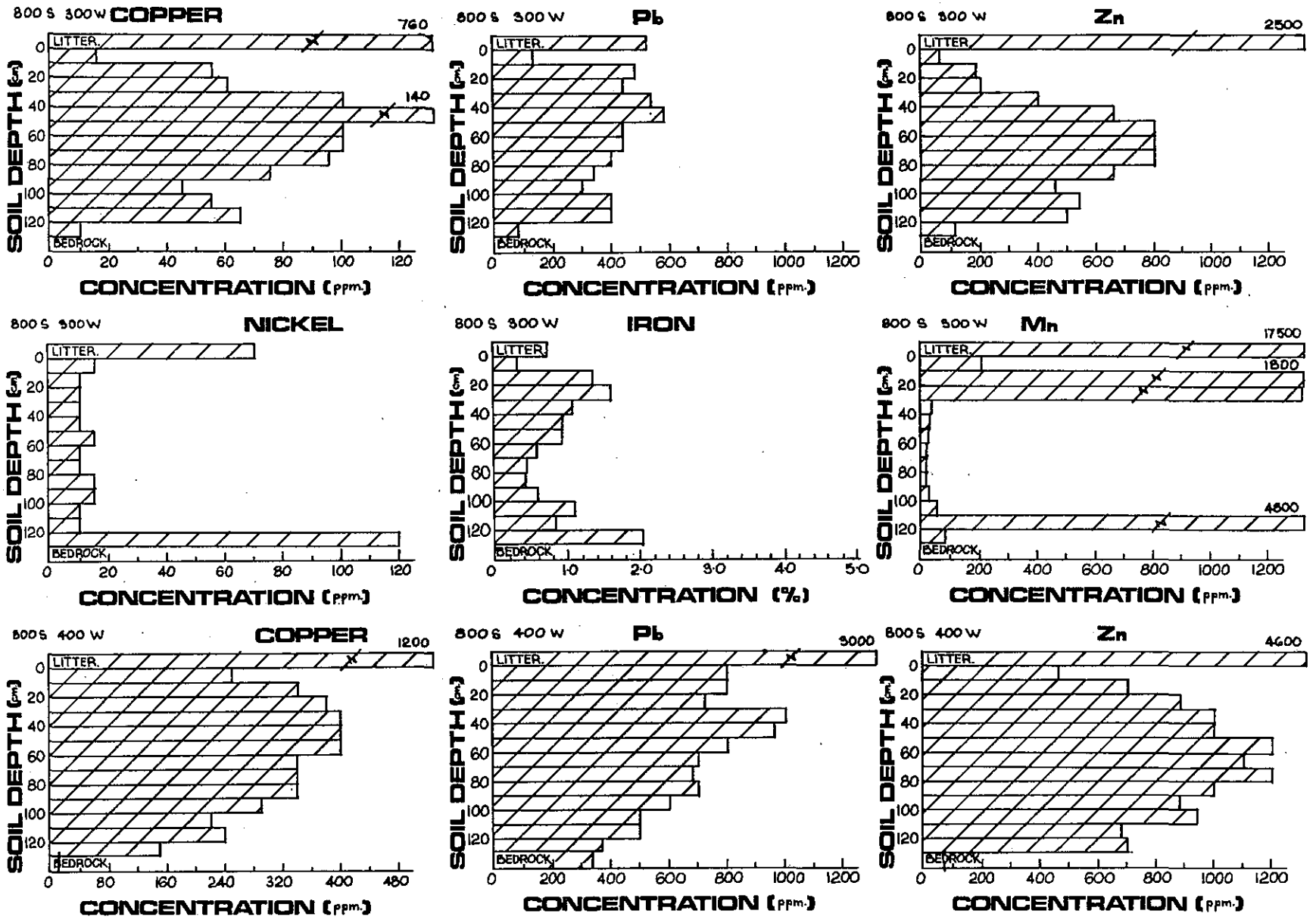


Figure: 3.58 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

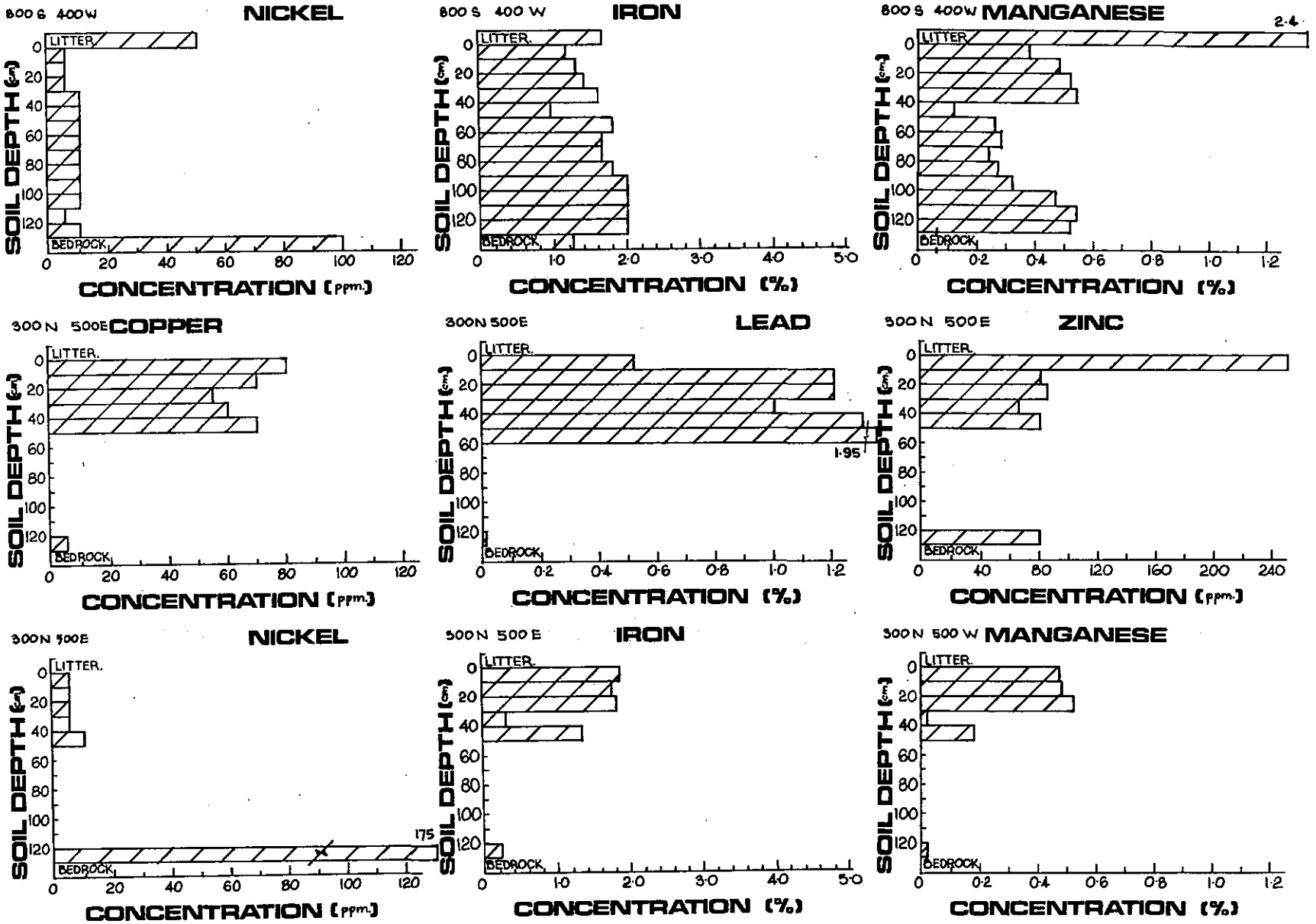


Figure: 3.59 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

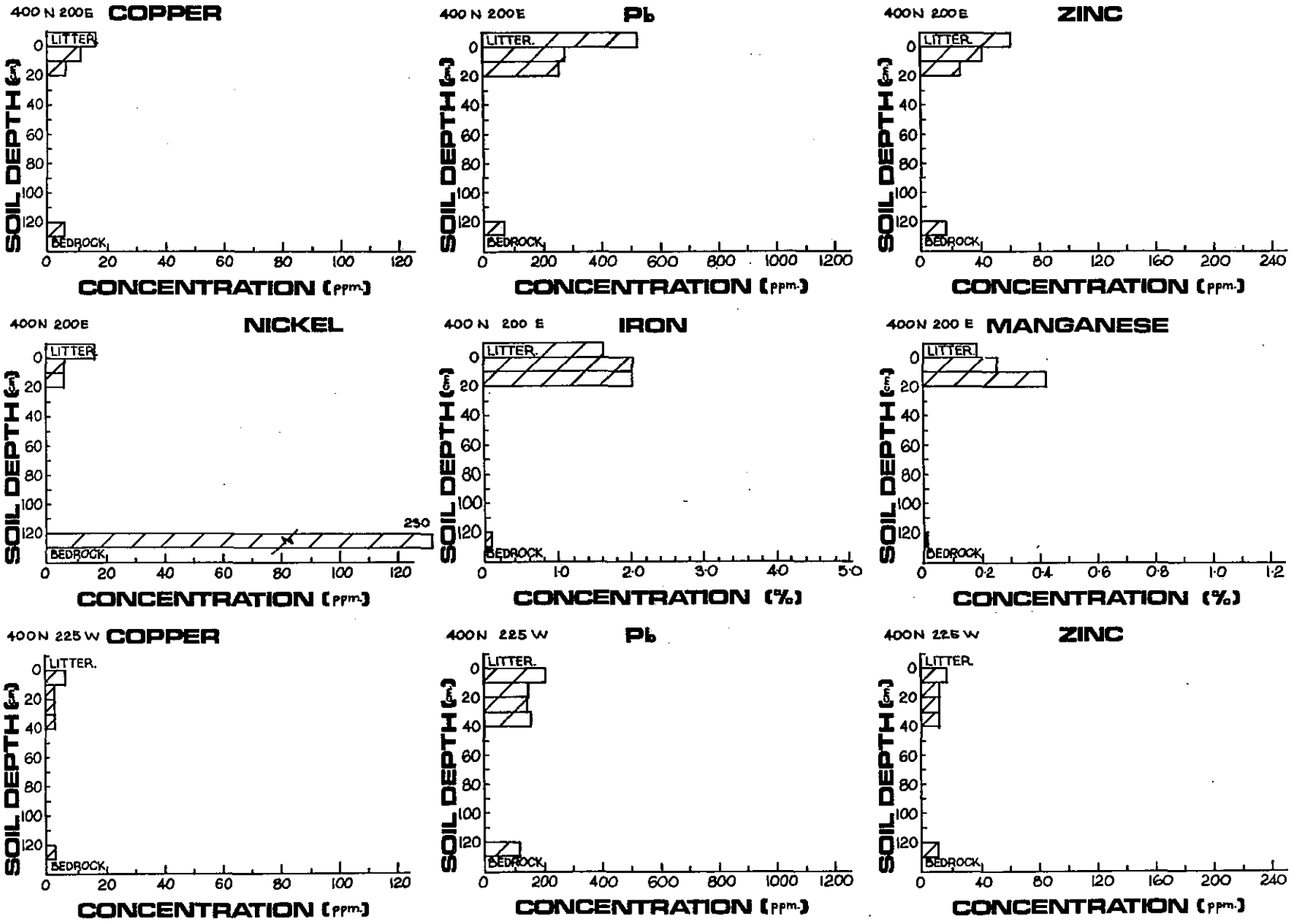


Figure: 3.60 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

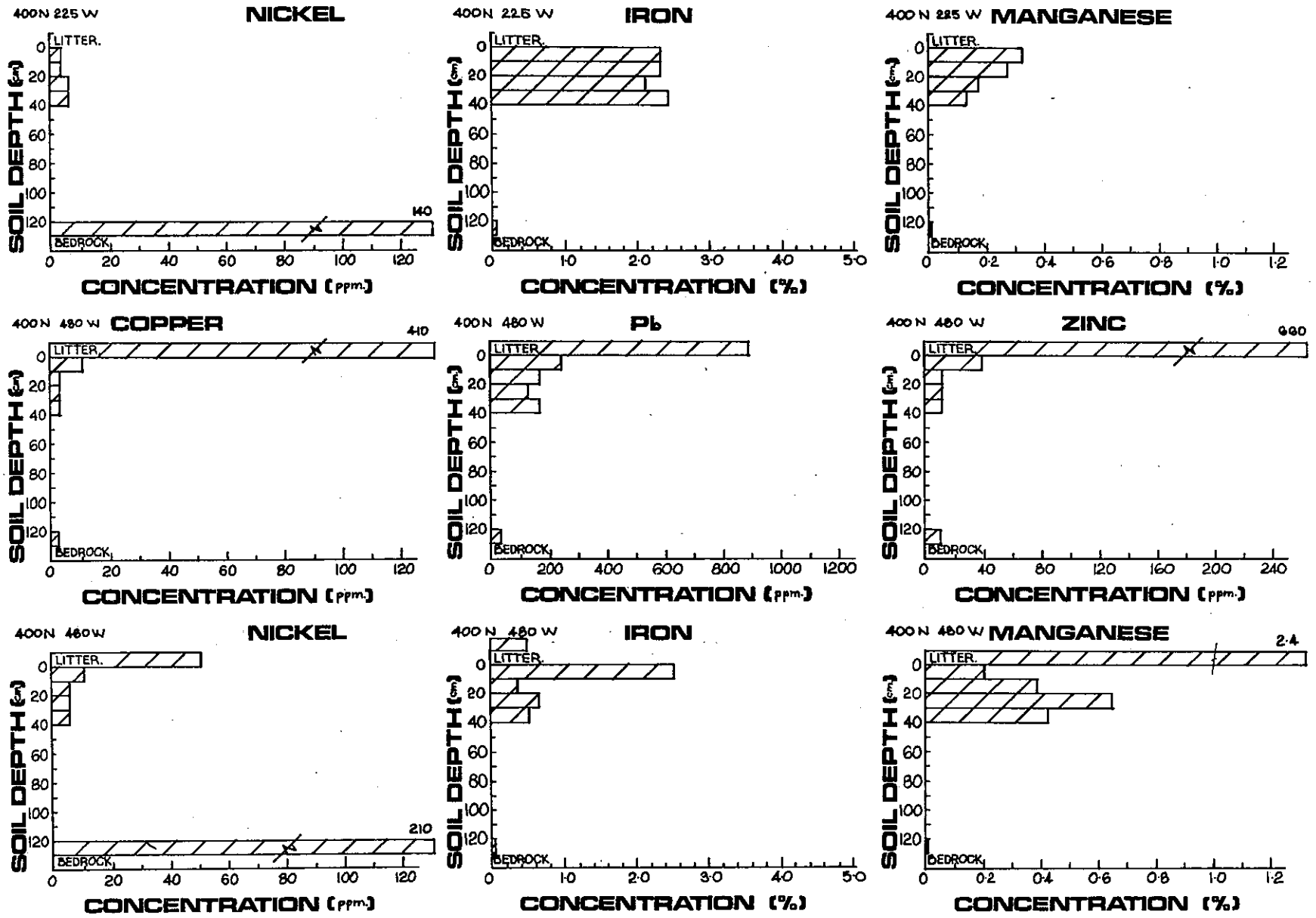


Figure: 3.61 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

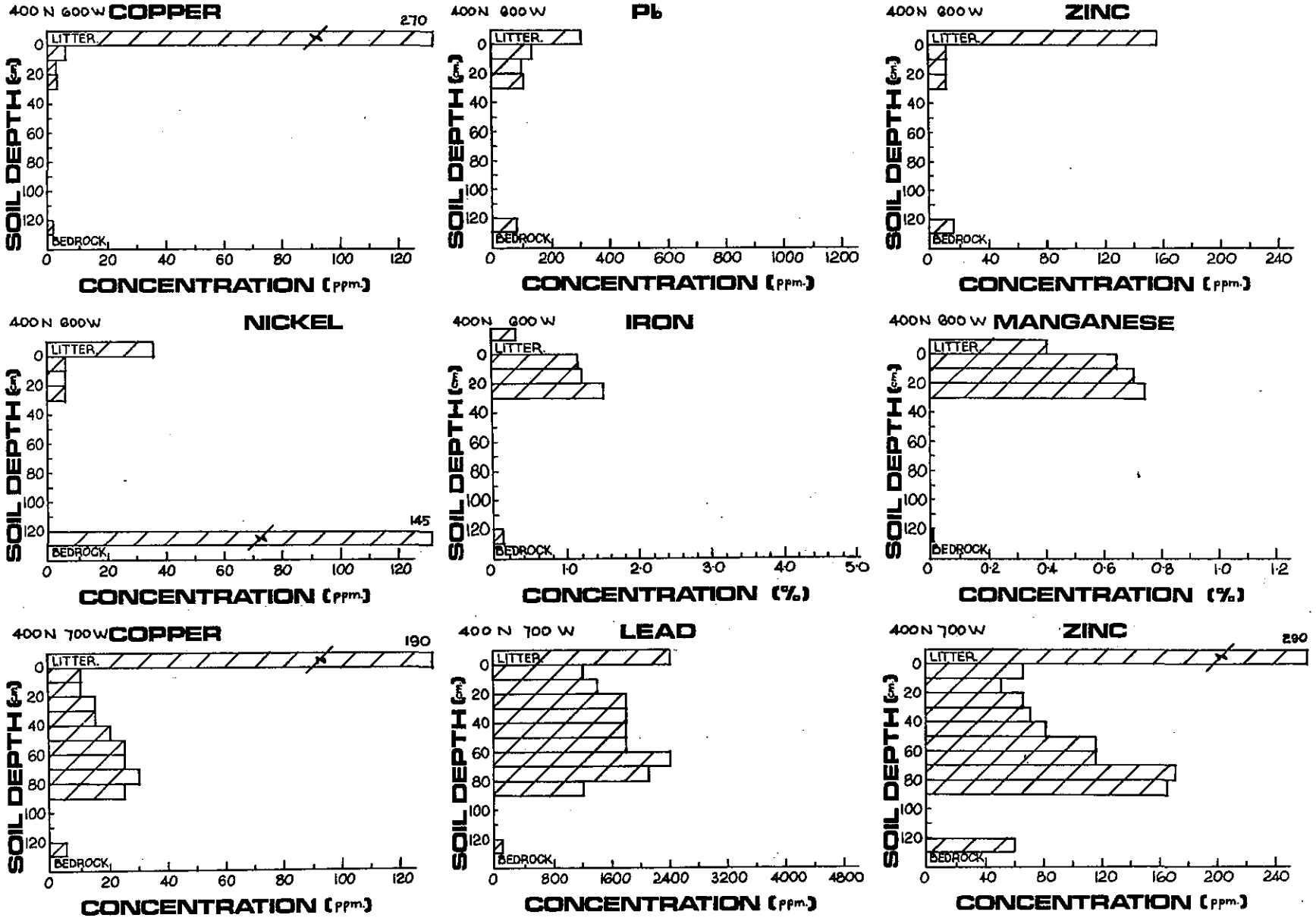


Figure: 3.62 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

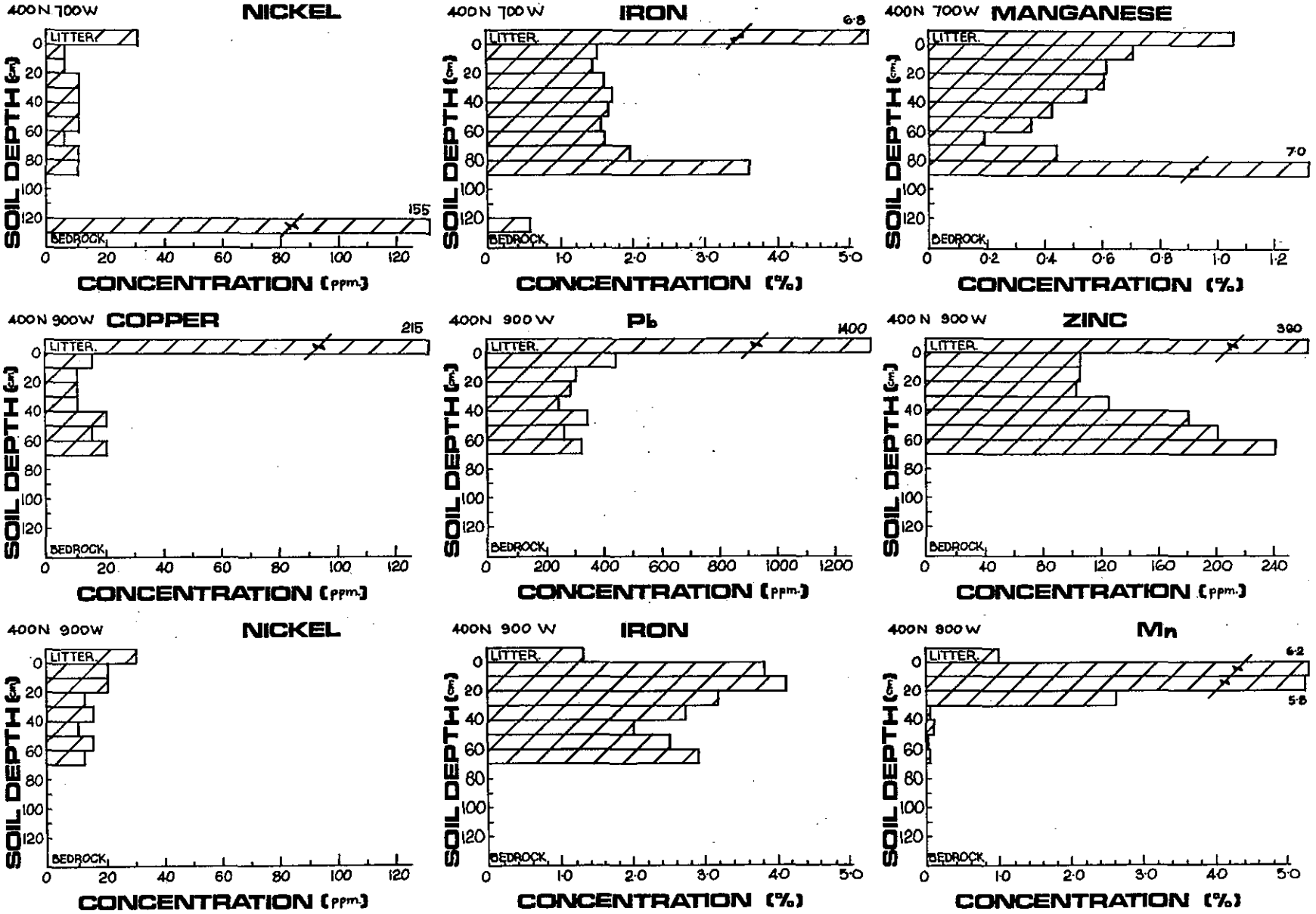


Figure: 3.63 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

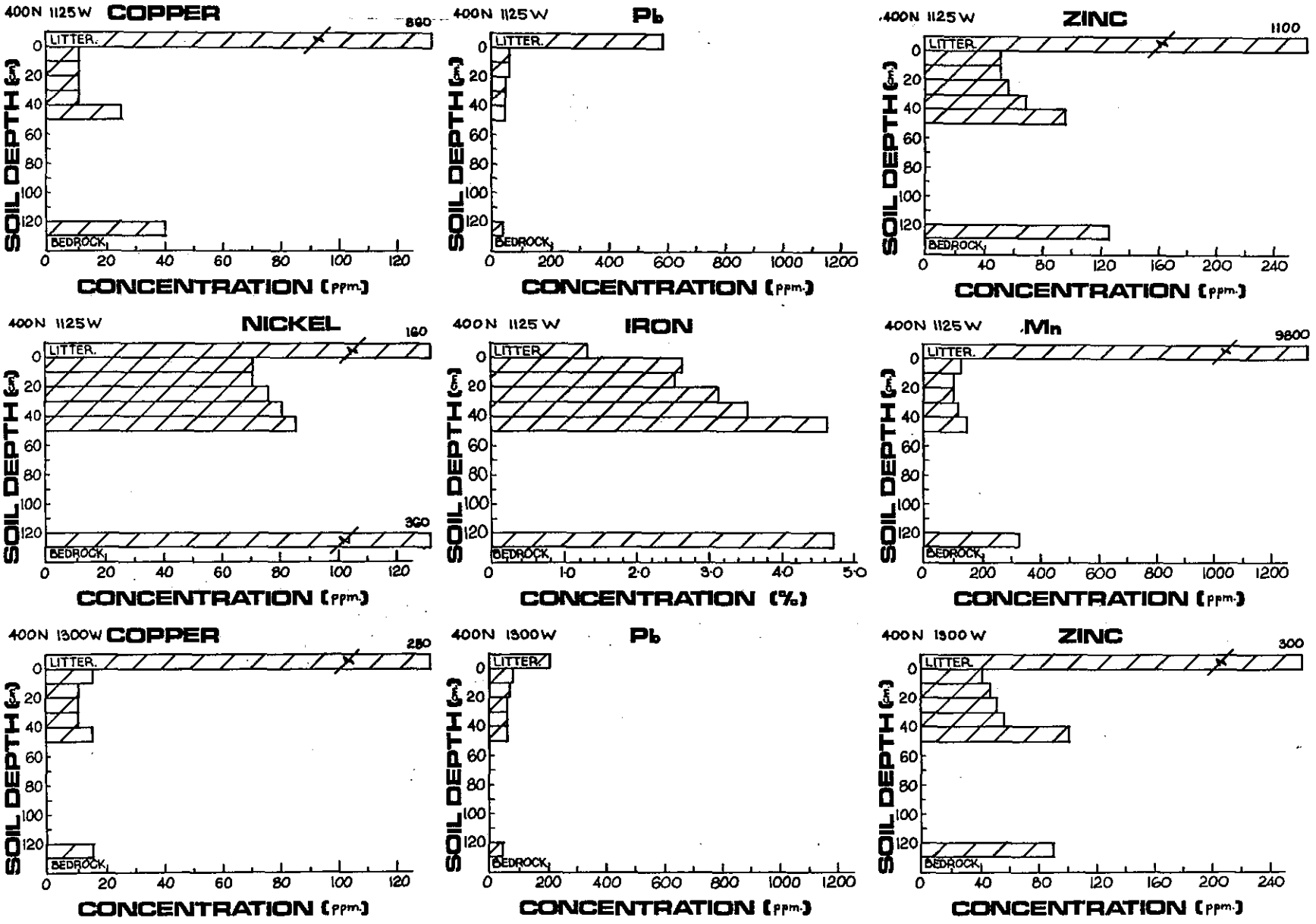


Figure: 3.64 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

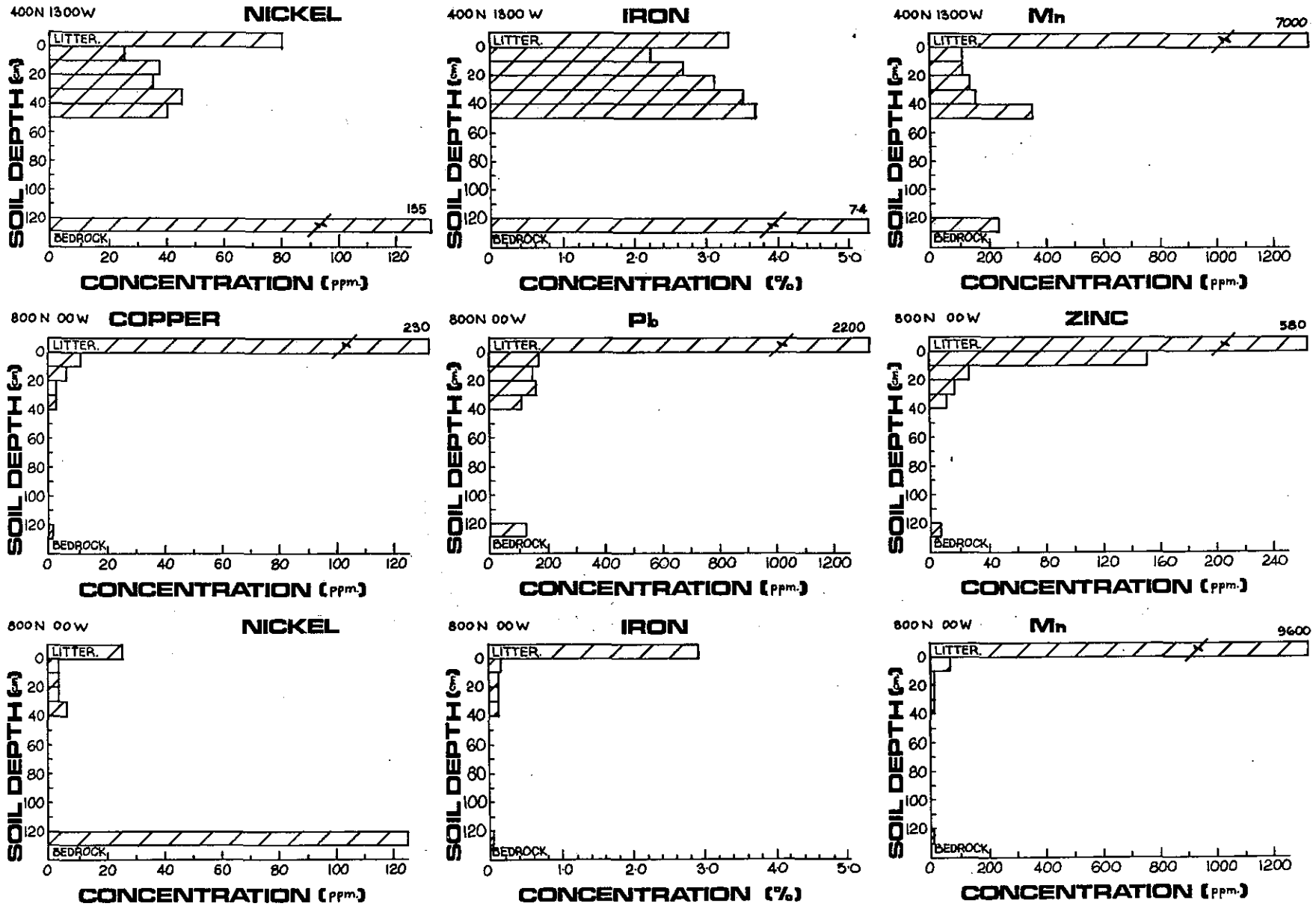


Figure: 3.66 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

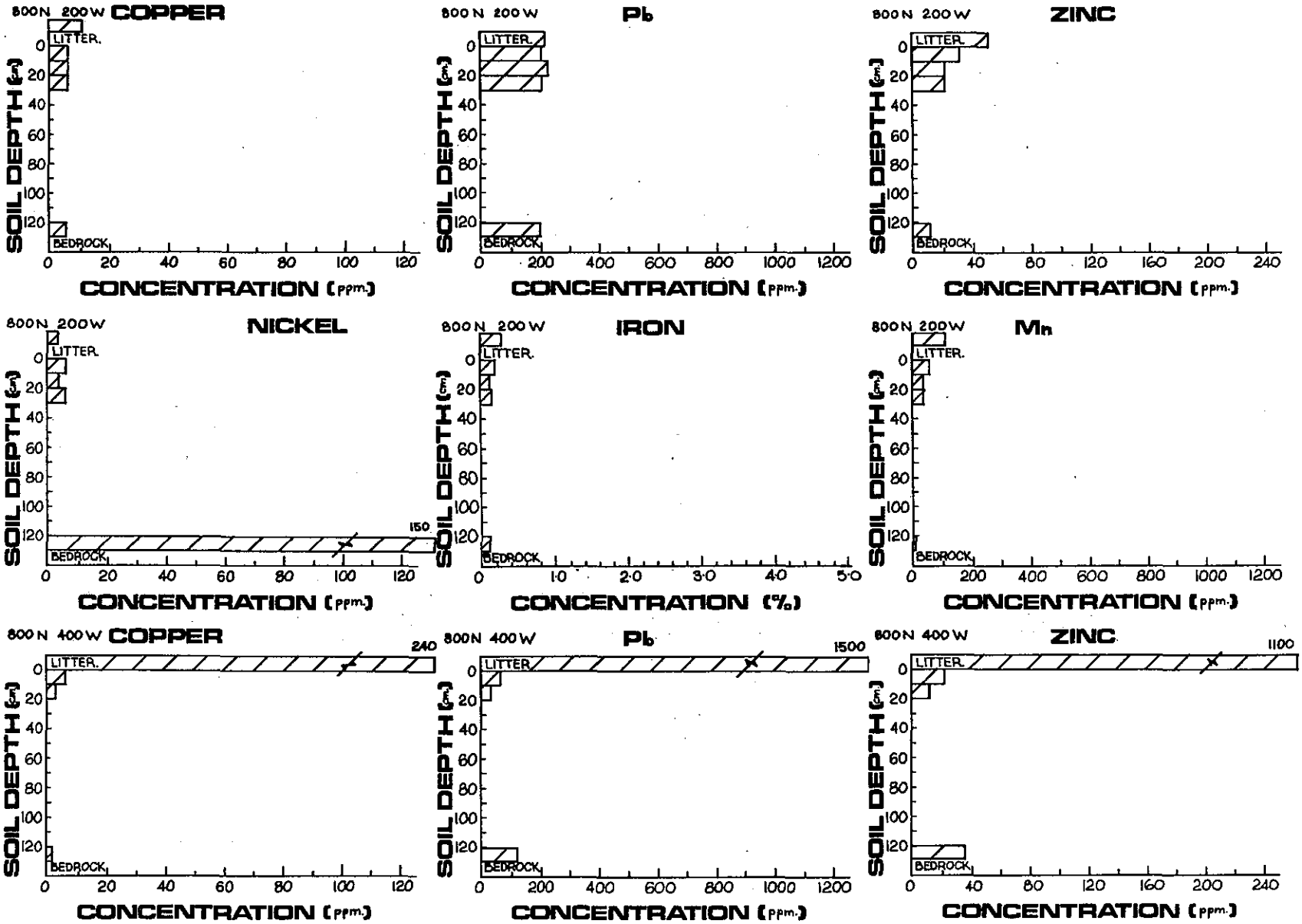


Figure: 3.66 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

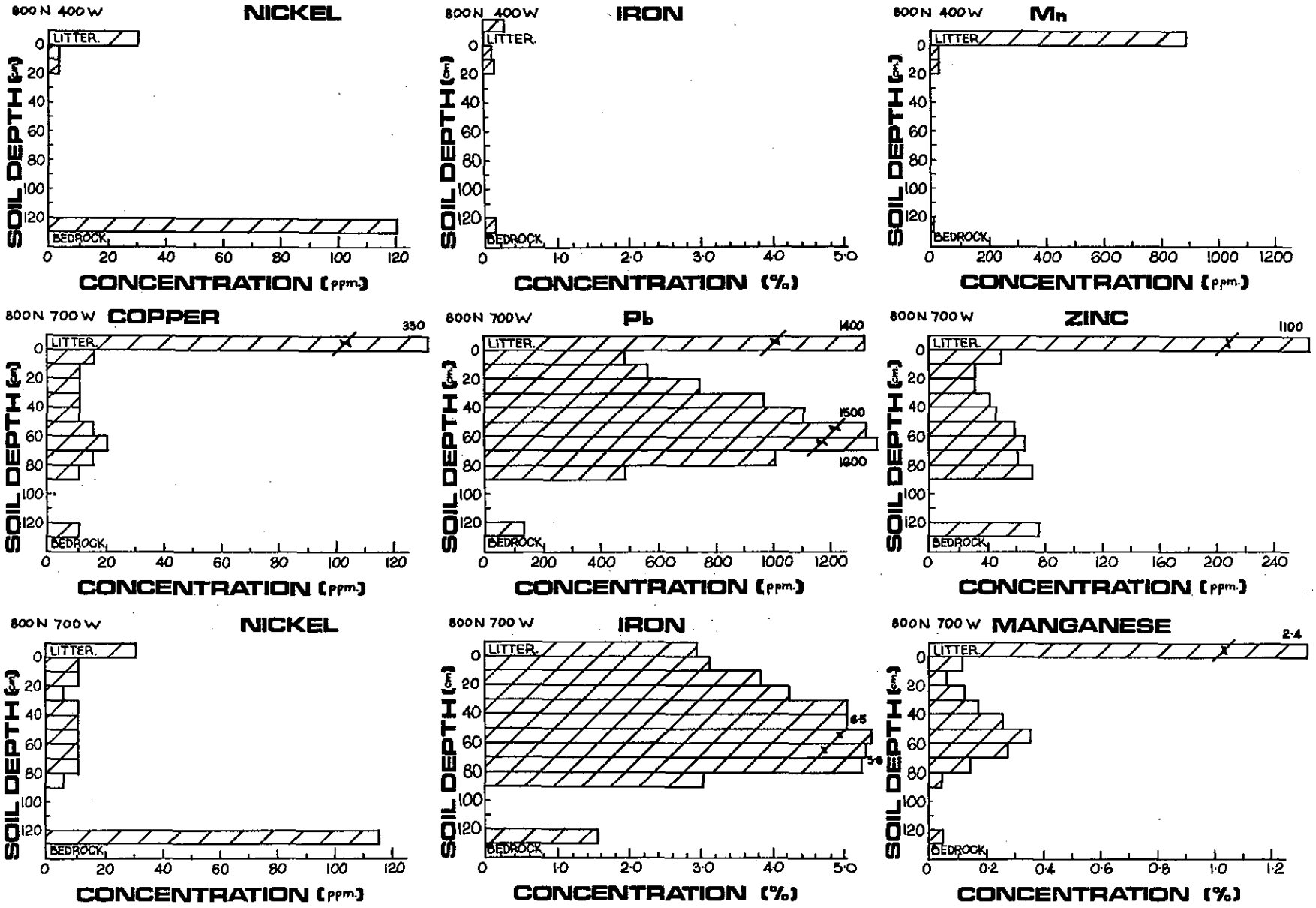


Figure: 3.67 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

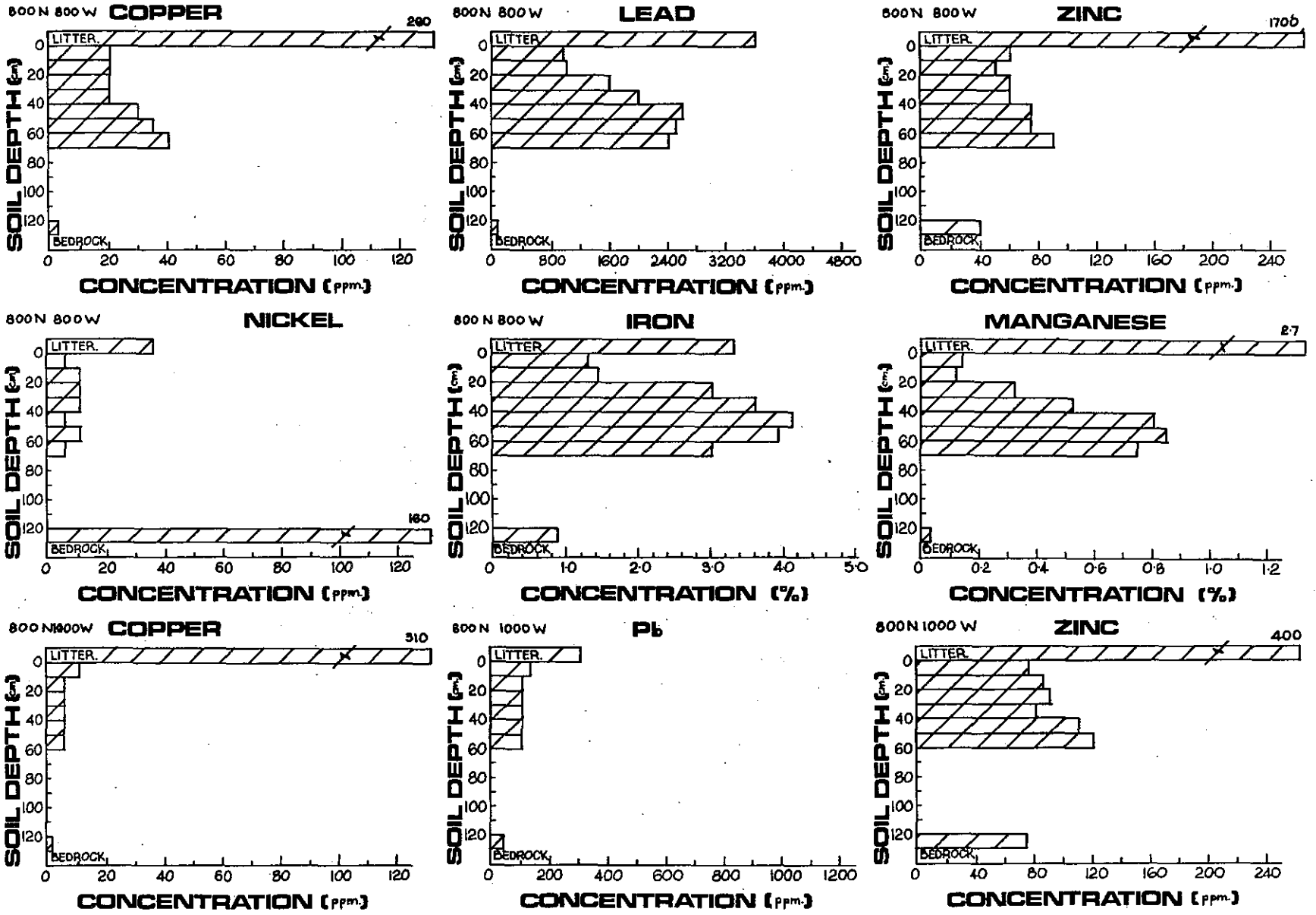


Figure: 3.68 ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

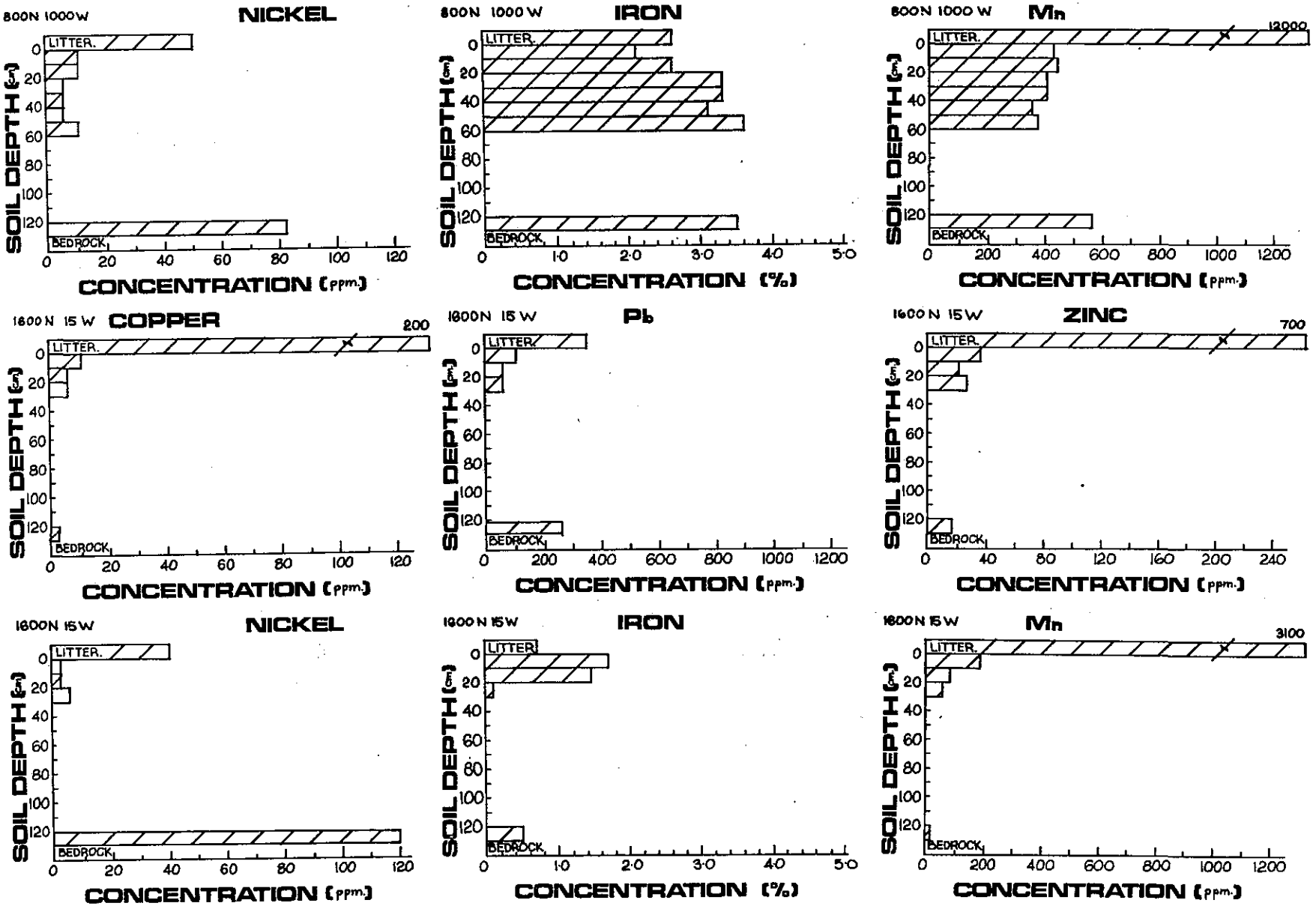


Figure: 3.69

ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES

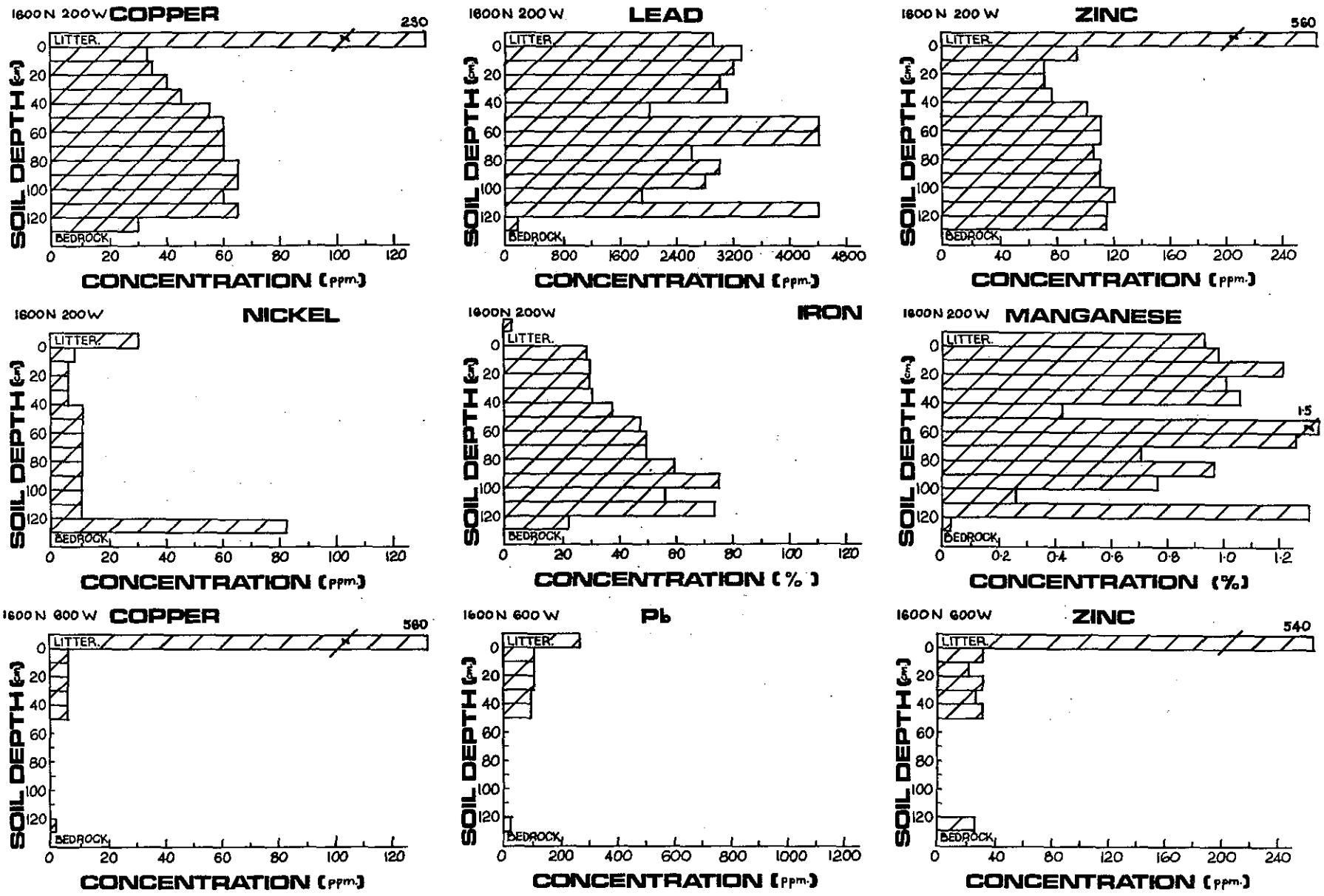
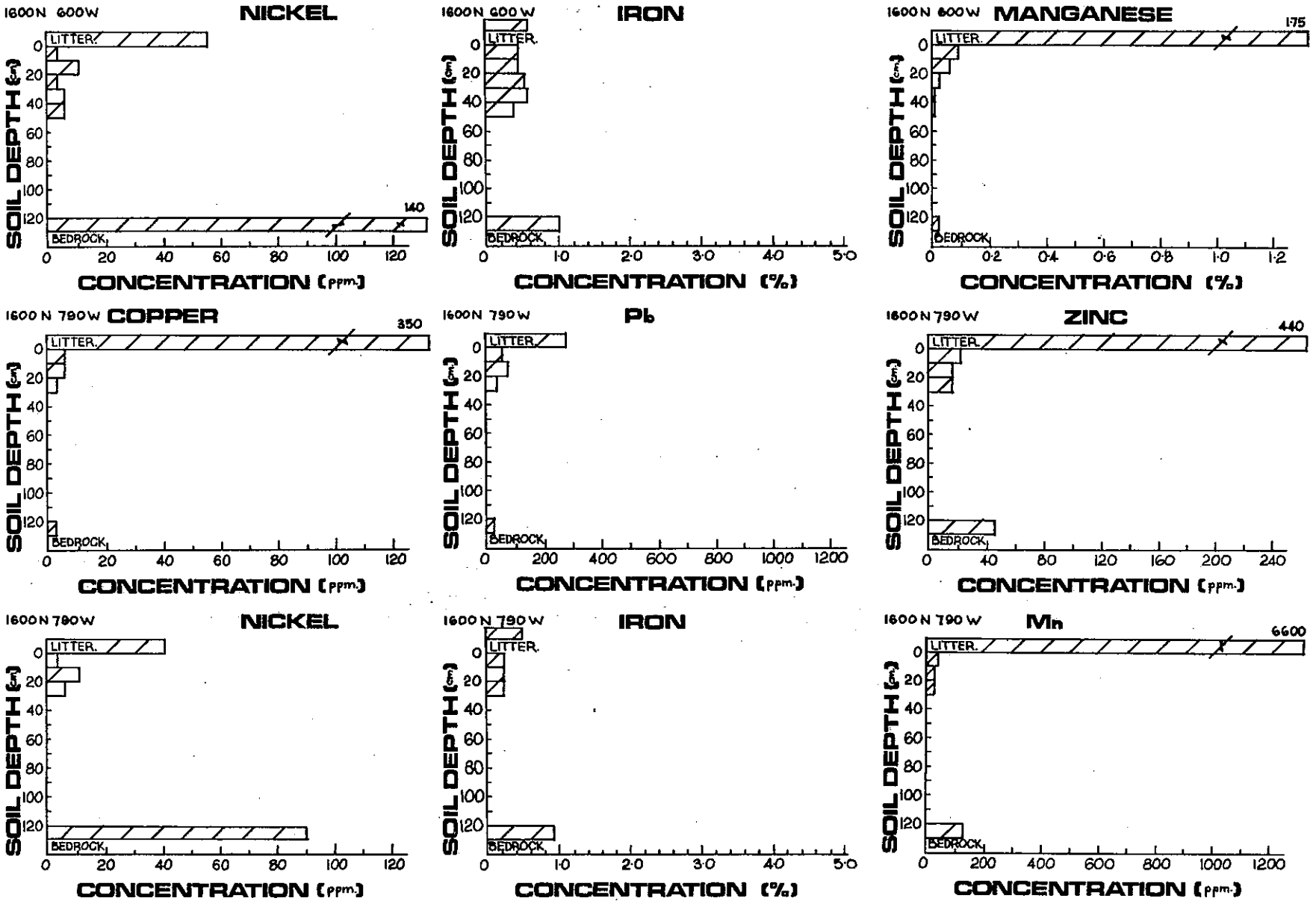


Figure: 3.70

ELEMENTAL CONCENTRATIONS DOWN SOIL PROFILES



3.7 CHEMICAL DISTRIBUTION OF TRACE ELEMENTS.

A sequential analysis of four soil profiles was carried out for Cu, Pb, Zn, Fe and Mn (400N 225W, 700W, 1125W and 800N 700W). The results are tabulated in Appendix D.5. The absolute concentrations were then converted to "relative concentrations" (%). This was done by expressing the extracted element in any one extraction, as a percentage of the total element concentration. The data were then plotted with the relative concentration on the vertical axis and the extraction method along the horizontal axis. (Figures 3.71 to 3.86, page 168 to 183).

The abbreviations used were: H_2O - Distilled water extraction of water solubles; Mn-Hydroxylamine hydrochloride extraction of manganese oxides; Org-Hydrogen peroxide extraction of organics; Fe-Hydrazine chloride extraction of iron oxides; Clay-Perchloric extraction of clay; and Residue-Perchloric extraction of silt and residue.

The sequential analysis gives an indication of the location of the metals over the various soil phases. It also indicates which elements have scavanging characteristics.

(i) Chemical Variation (Figures 3.71 to 86, Page 168)

(a) Copper.

An appreciable amount of the minor copper present was water soluble. This was especially so in the top soils of the shallower soils where there was less clay. The important soil phase for the copper gradually changed from the clay at the top, to the residue at the base of the profile.

(b) Lead.

In the shallow soils, lead is present in the clay and residue throughout, with the importance of the residue increasing with depth.

At the top of the deep soils, lead is present in the manganese, clay and residue soil phases. With an increase of depth, the manganese assumes greater importance and the residue and clay contain less lead.

Hence, manganese when present, is a strong scavenging agent for lead, with iron and clay being of secondary scavenging importance.

(c) Zinc.

This element is distributed over the clay, manganese, iron and residue soil phases. In general, the importance of the manganese phase decreases with depth as the importance of the residue phase increases. Once again the manganese is proving itself to be an efficient scavenger.

(d) Iron.

The importance of the residue phase increases with depth. The clay phase remains relatively constant with depth, in its importance of containing iron. The exchangeable iron fraction decreases in importance with depth. Some iron is bound into the manganese fraction, but this is "swamped" when compared with that bound to the residue phase.

(e) Manganese.

When organic matter is present in sufficient quantities, it becomes a relatively important complexing

agent for manganese. Clay is only of significance in one hole, towards the base where the clay content is the greatest.

The importance of the residue phase also increases with depth. The amount of manganese present in both the iron and manganese phases decreases with depth.

(ii) Discussion.

Copper, manganese and iron occur as water soluble compounds. Iron shows the highest absolute values (Appendix D.5), but with respect to the total amount of iron present, these values are negligible.

Manganese oxides display strong affinities for lead, zinc and iron which can be interpreted as scavenging characteristics.

The organic material in the profiles is an effective complexing agent, mainly for manganese but also for iron.

Some zinc and large amounts of manganese and lead were extracted with the iron, especially in the deeper soils. This indicates that iron oxides are an important scavenger in these soil profiles.

While iron oxides sorb higher concentrations of lead and manganese than the manganese oxides sorb lead and iron, this is only an expression of iron's great abundance with respect to manganese. Hence, the manganese oxides are, pro rata stronger scavengers than iron oxides. However, what iron oxides lose in "scavenging activity" they make up with abundance.

The clay soil phase contains minor zinc and manganese. There is a direct relationship between the clay and copper contents of the holes. The clay also contains

a relatively constant amount of iron down any one hole.

The increase with depth of copper, lead, zinc, iron and manganese in the residue fraction of the holes is a reflection of the less weathered state of the deeper levels of the profiles. The high proportion of residual material is caused by analysis of the entire soil sample instead of being restricted to the -20 mesh fraction.

(iii) Conclusions.

The low concentration of all elements analysed in 400N 225W is caused by the absence of secondary soil components able to scavenge. This soil profile is also shallow and immature.

The high elemental concentrations in the deep, mature soils 400N 700W and 800N 700W are of a secondary nature and related to the influx and subsequent scavenging by manganese, iron and organic material.

The low elemental values in 400N 1125W (below the anomaly) can best be explained by assuming that all the metals have been removed from the ground-water by scavenging agents further upslope.

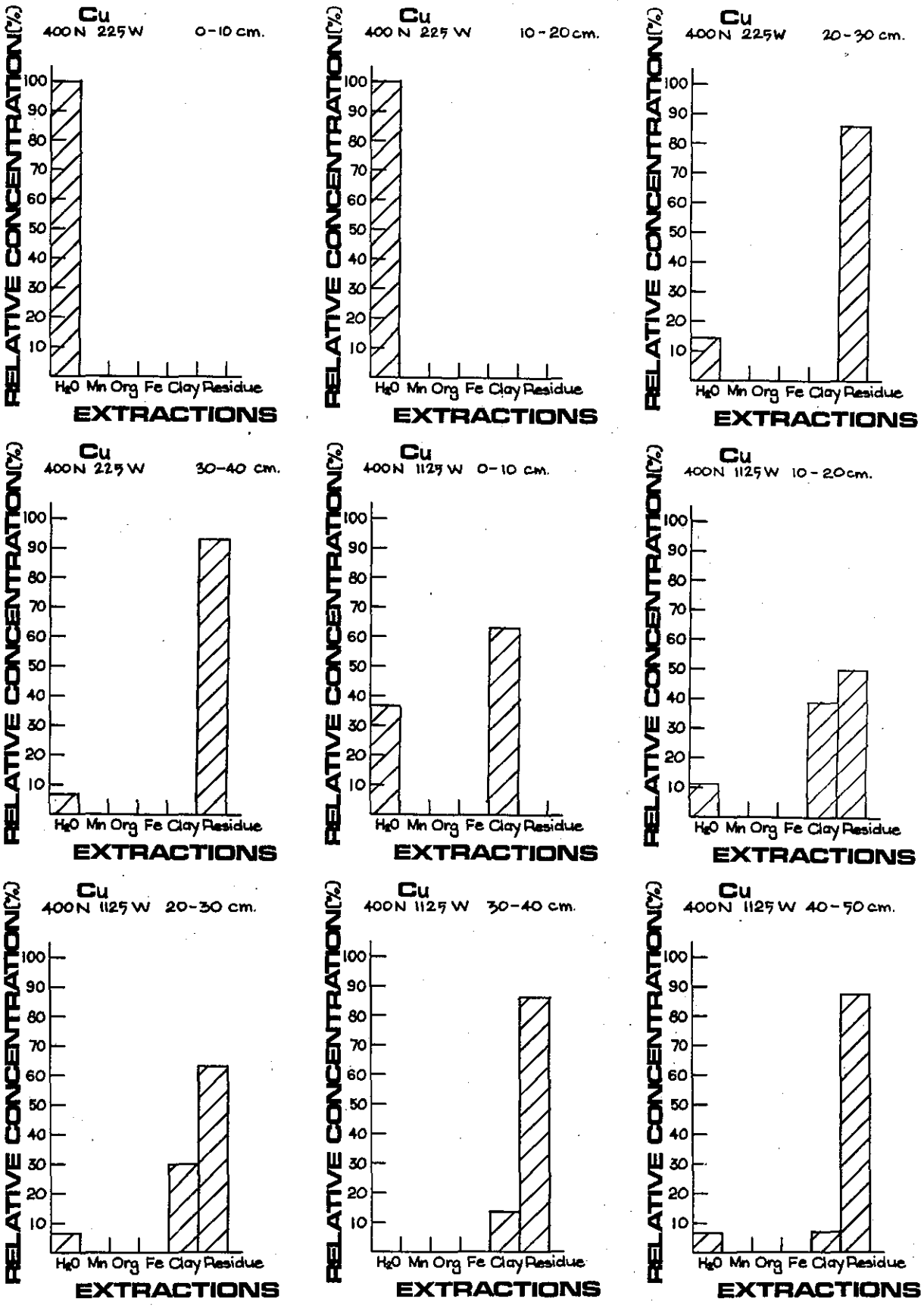


Figure: 3.71 Relative Concentration for each Extraction

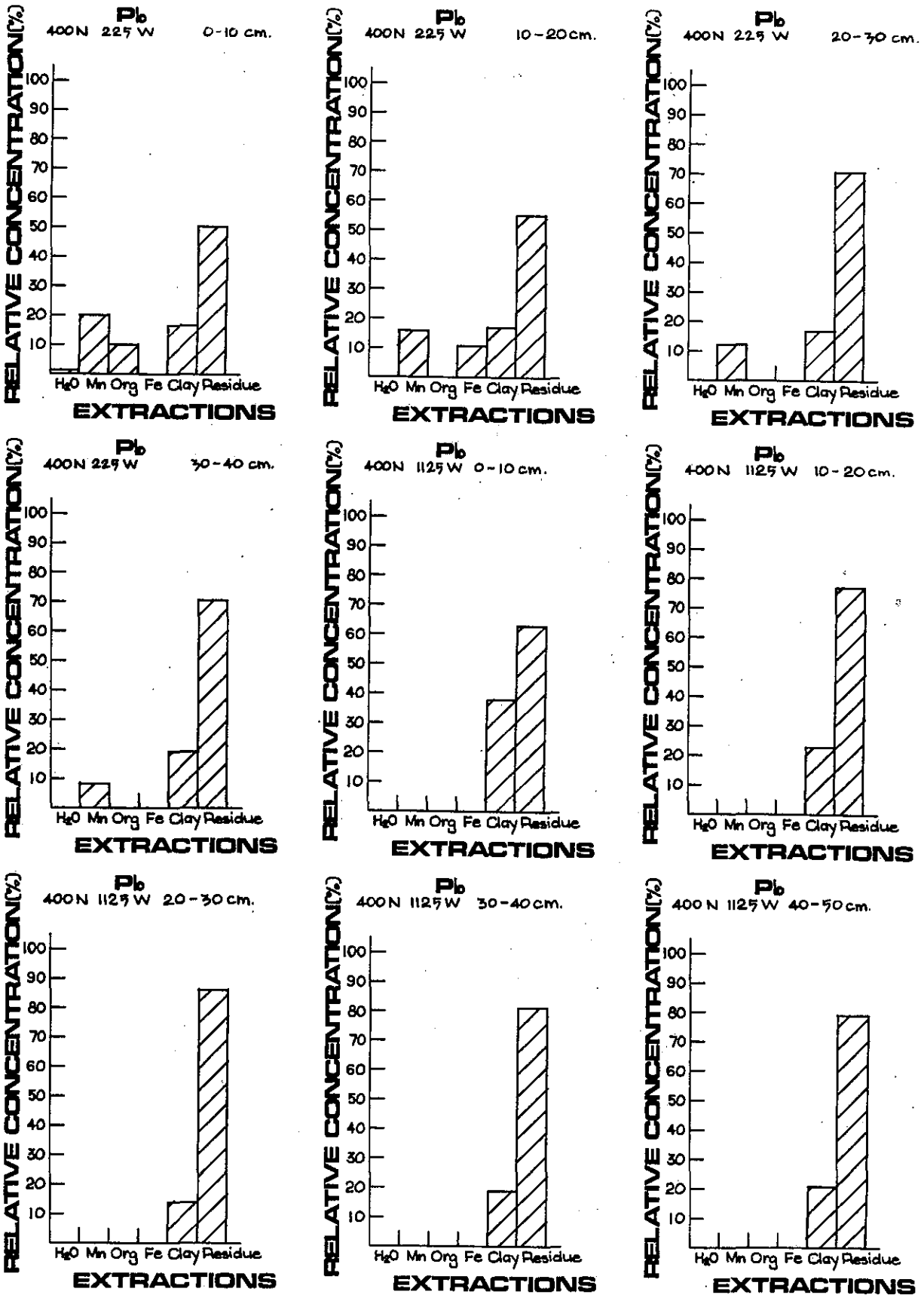


Figure: 3.72 Relative concentration for each Extraction

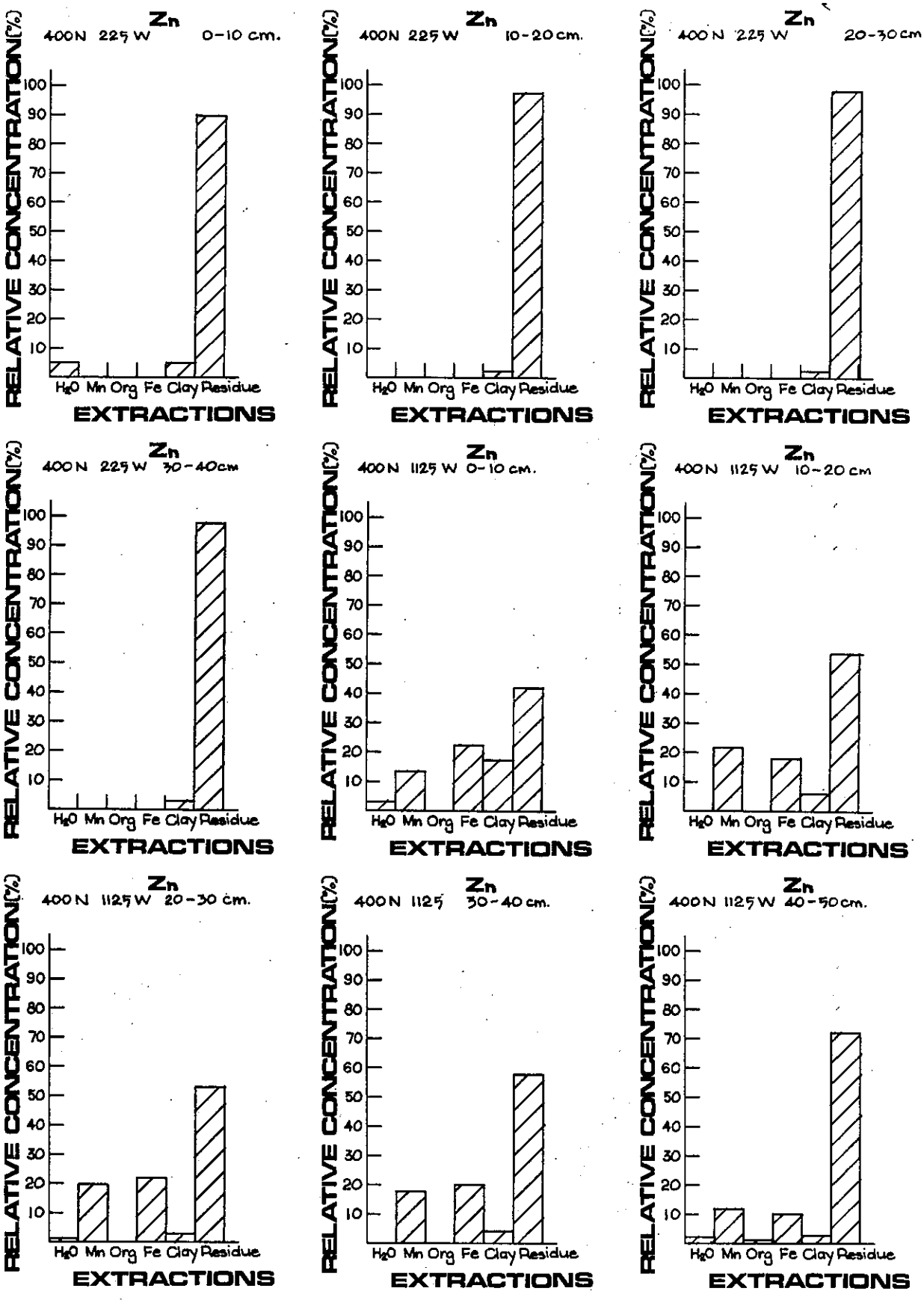


Figure: 3.73 Relative Concentration for each Extraction

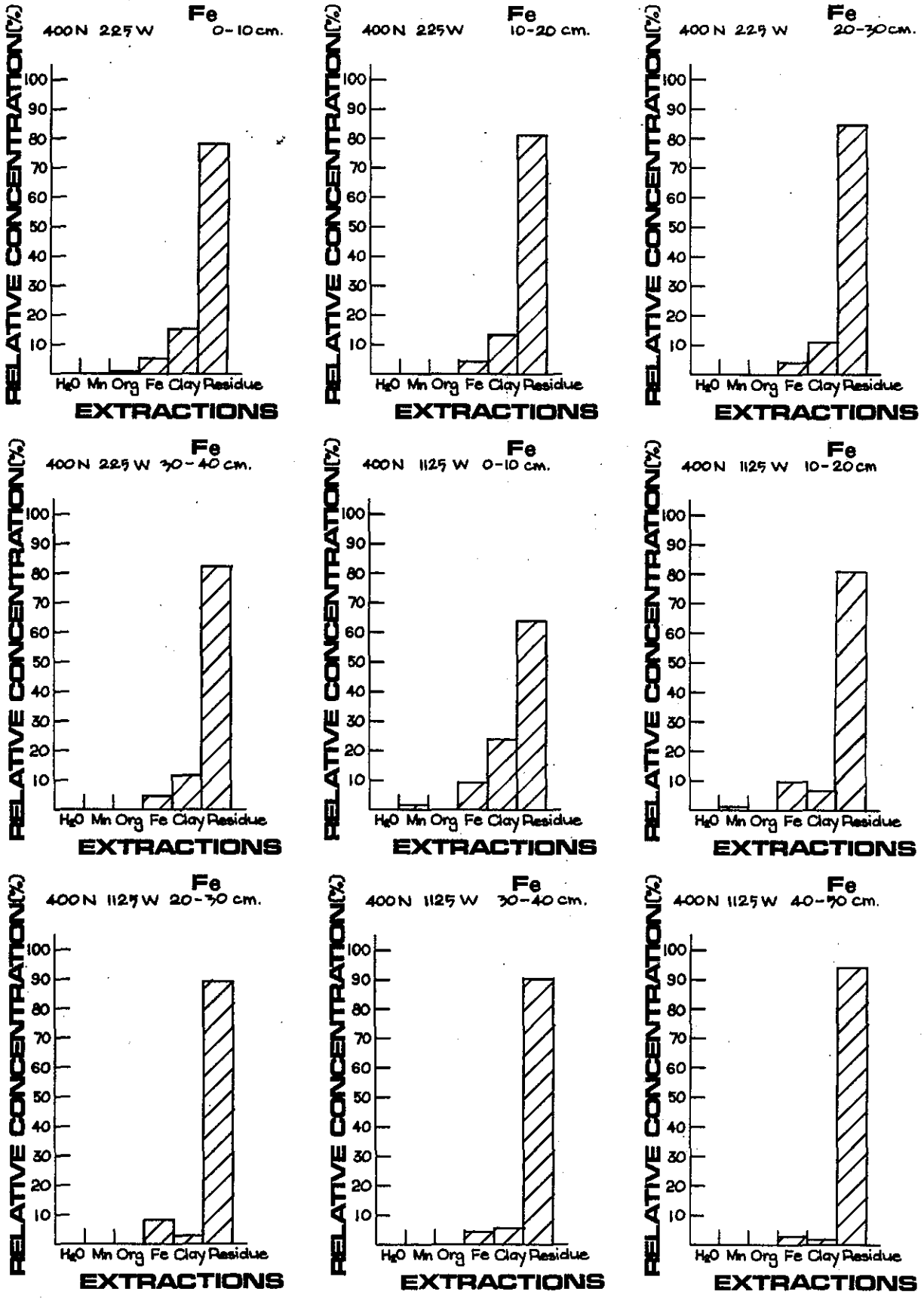


Figure: 3.74 Relative Concentration for each Extraction

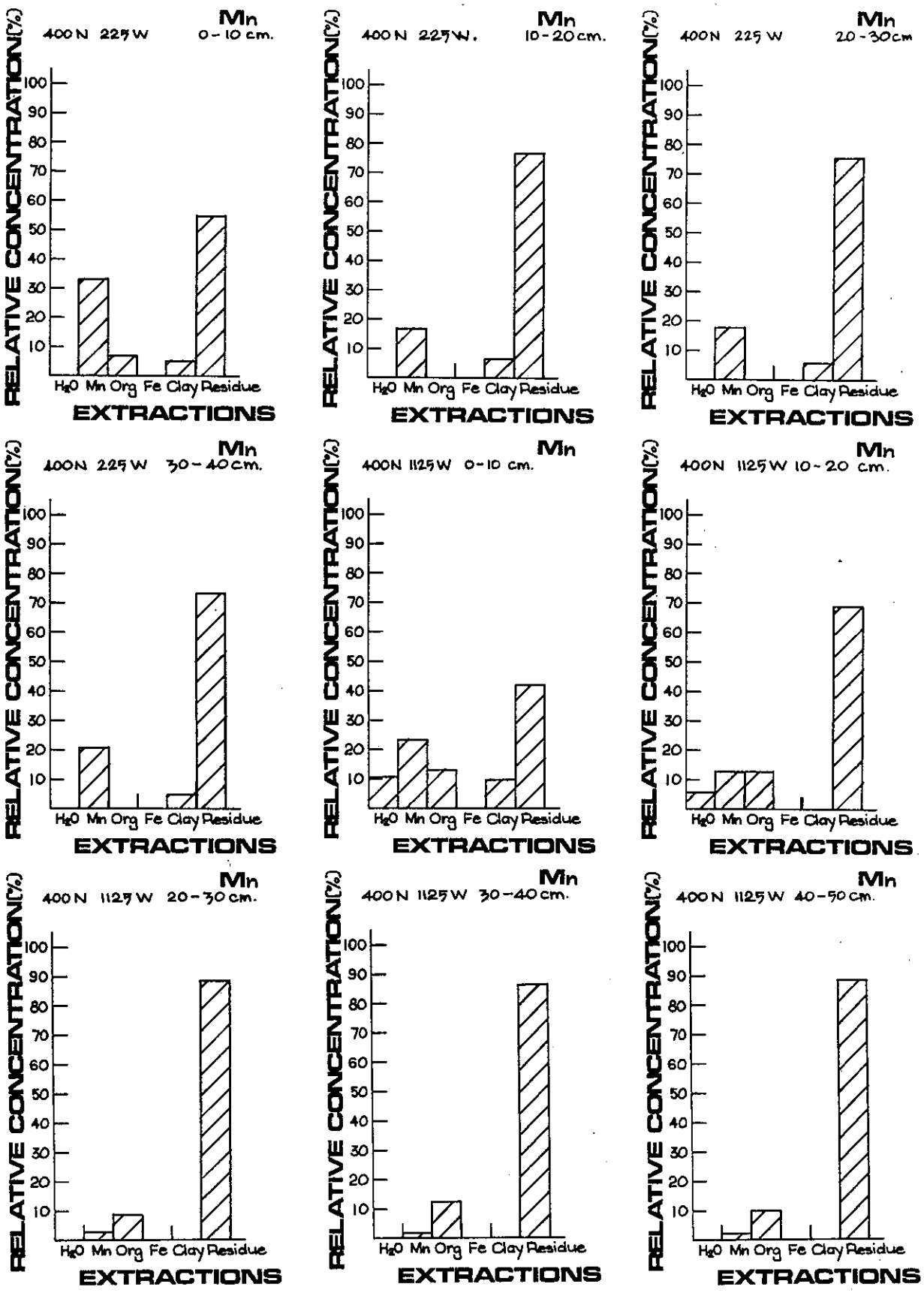


Figure: 3.75 Relative Concentration for each Extraction

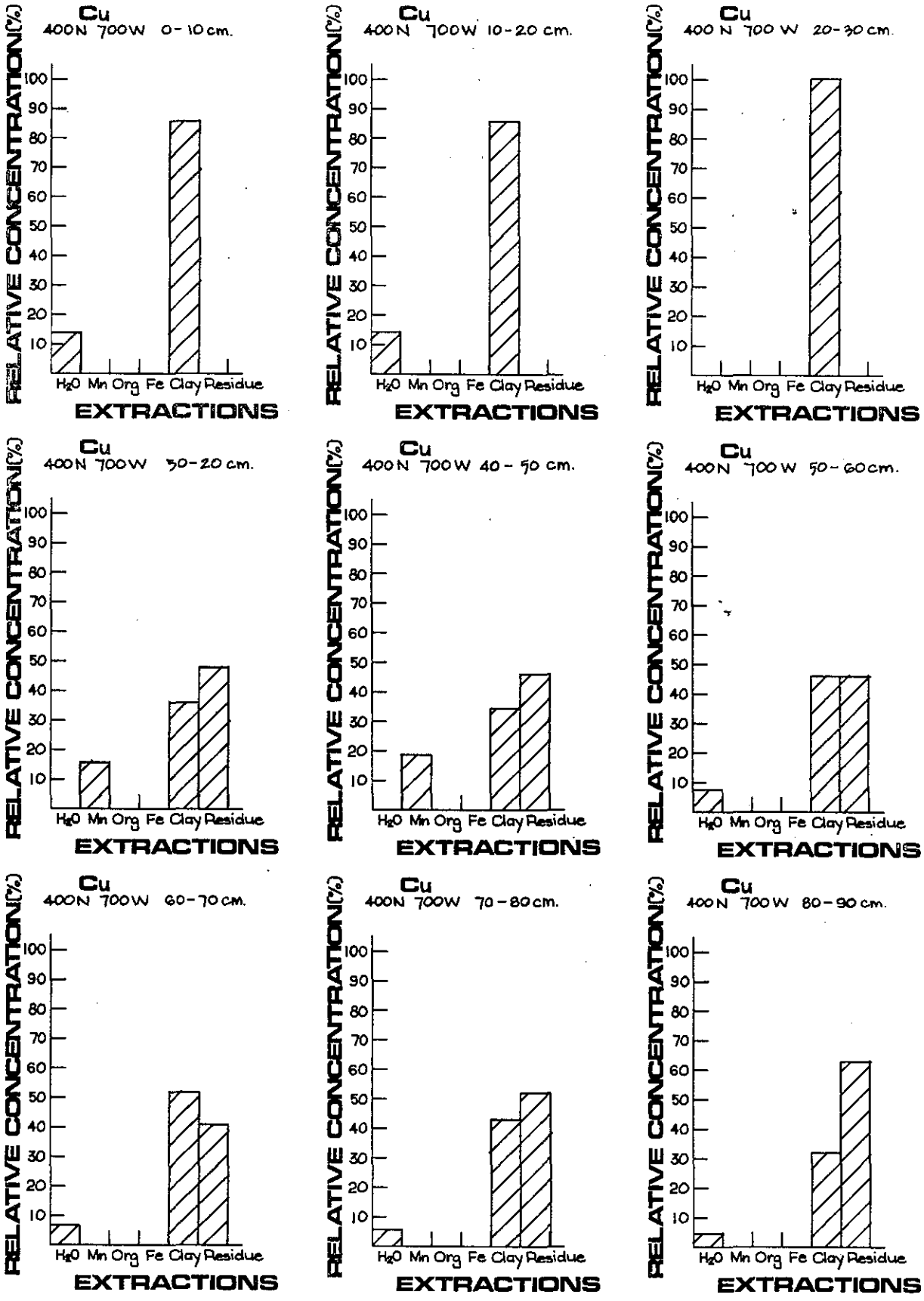


Figure: 3.76 Relative Concentration for each Extraction.

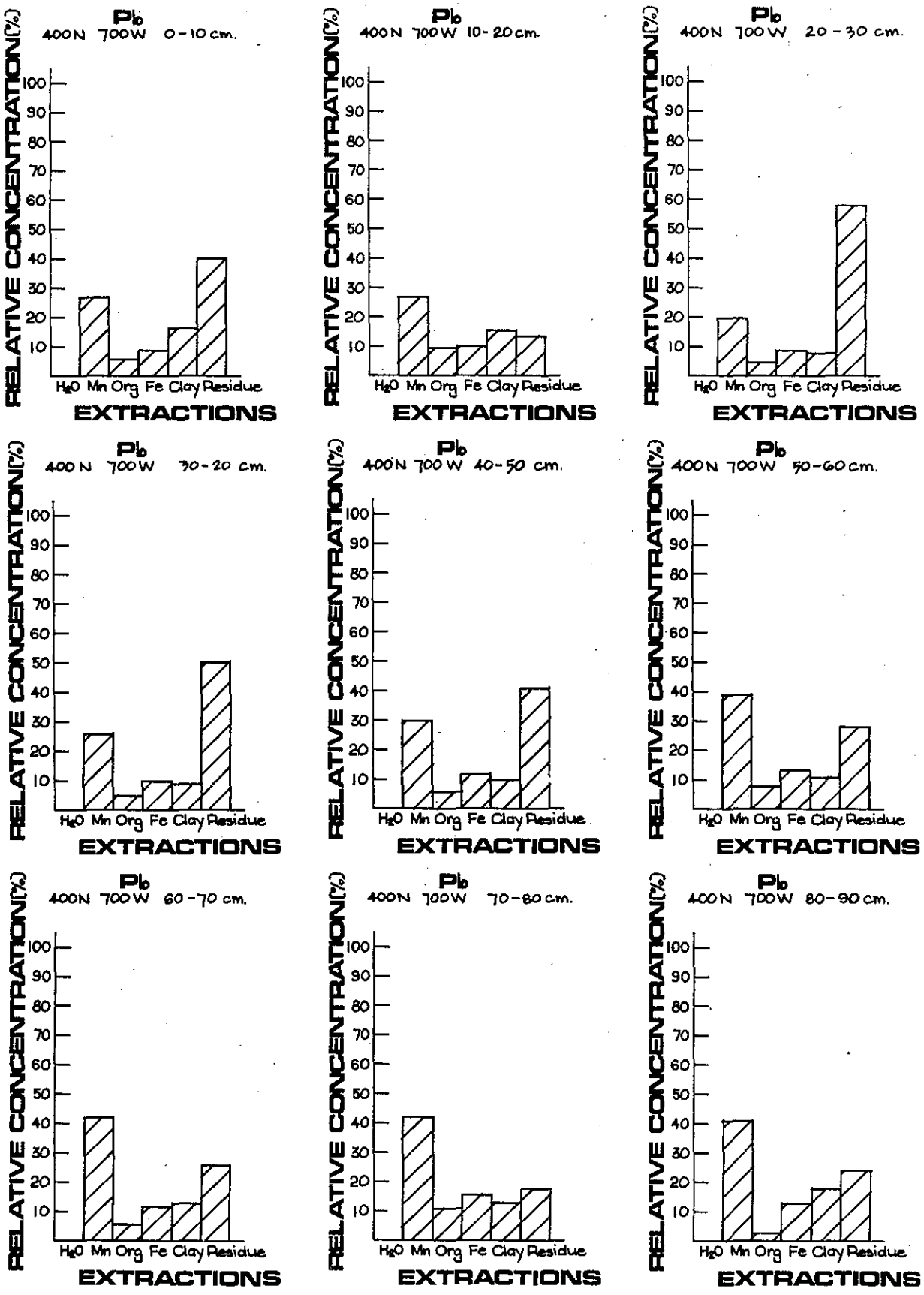


Figure: 3.77 Relative Concentration for each Extraction

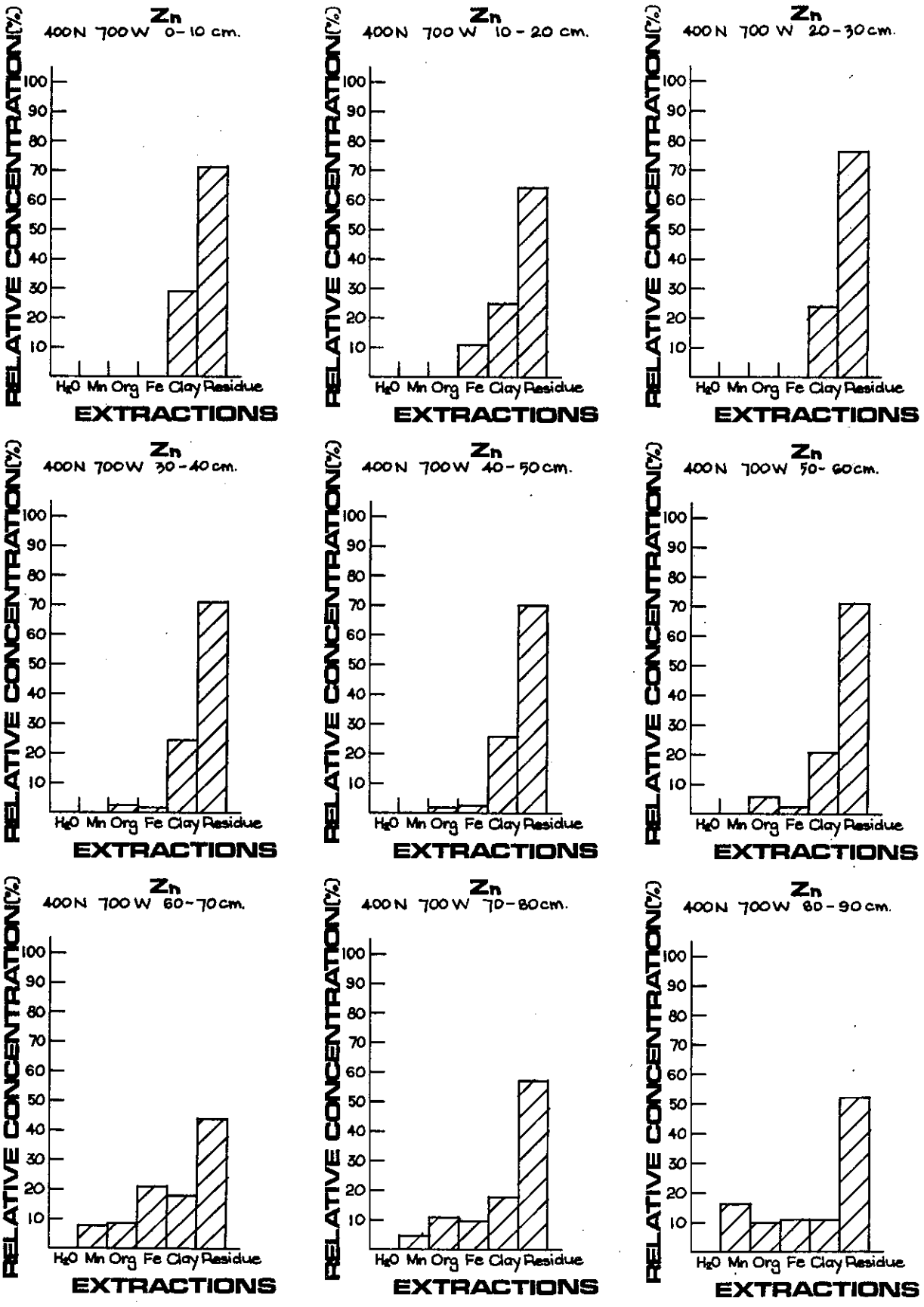


Figure: 3.78 Relative Concentration for each Extraction

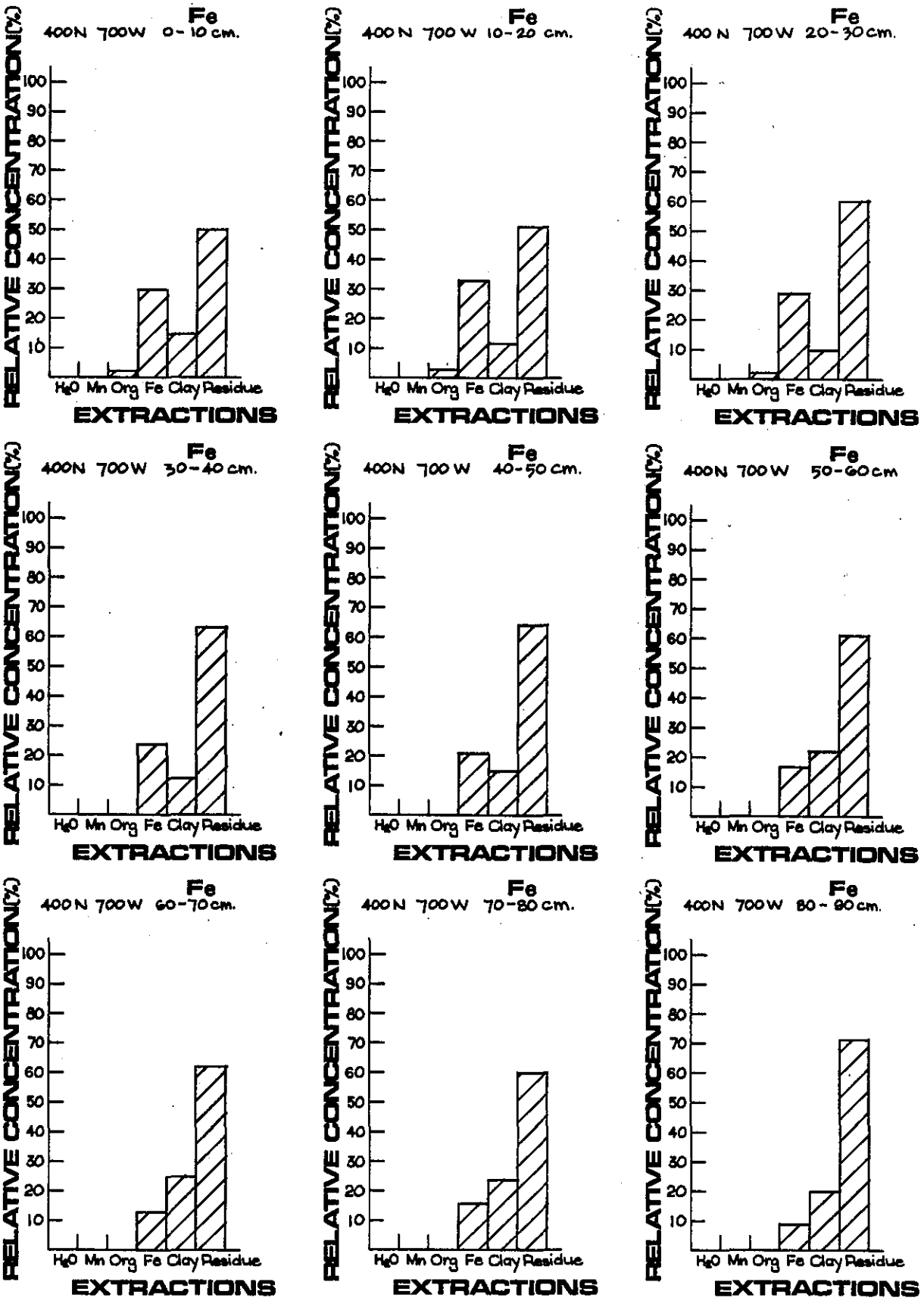


Figure: 3.79 Relative Concentration for each Extraction

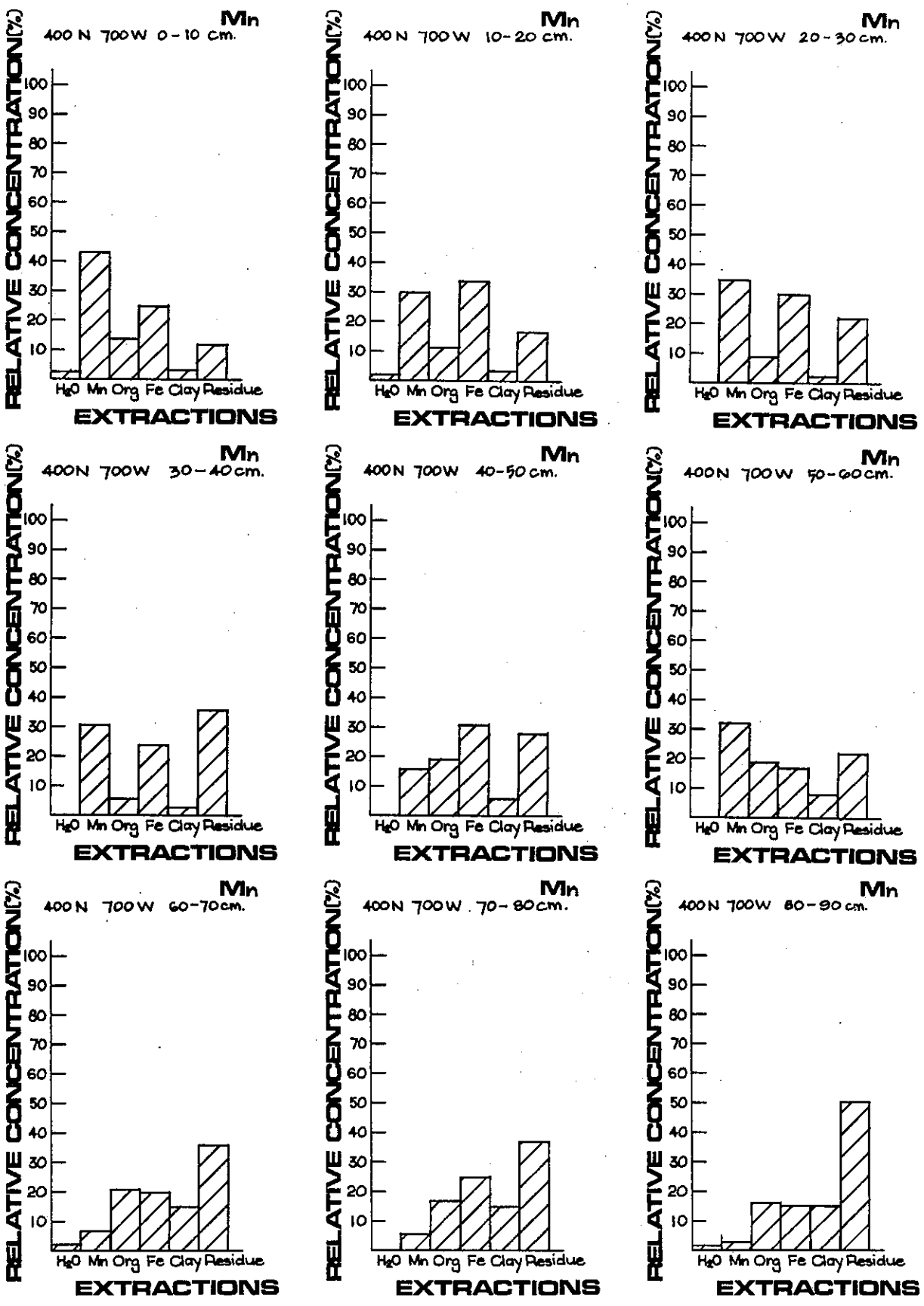


Figure: 3.80 Relative Concentration for each Extraction

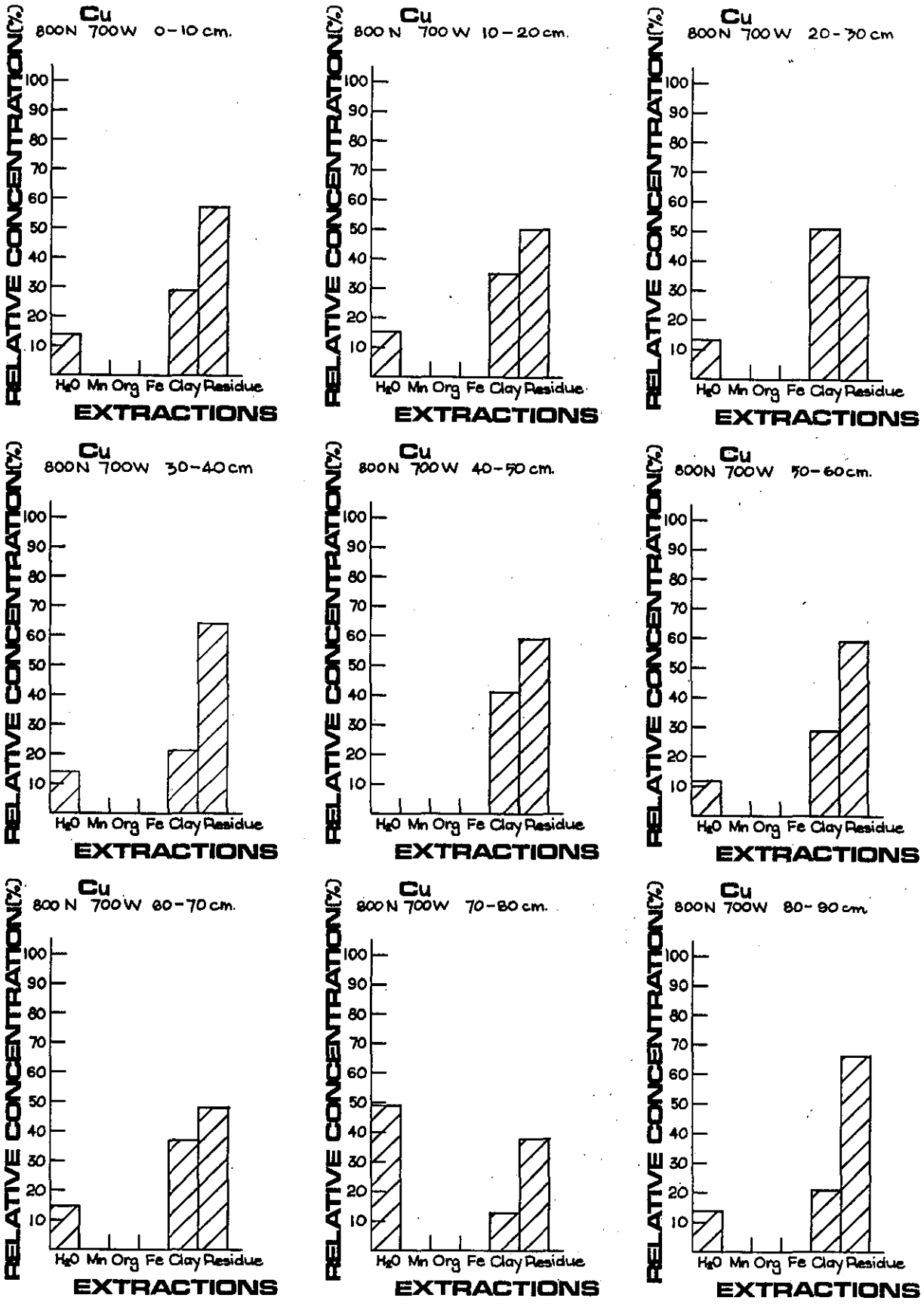


Figure:3.81 Relative Concentration for each Extraction

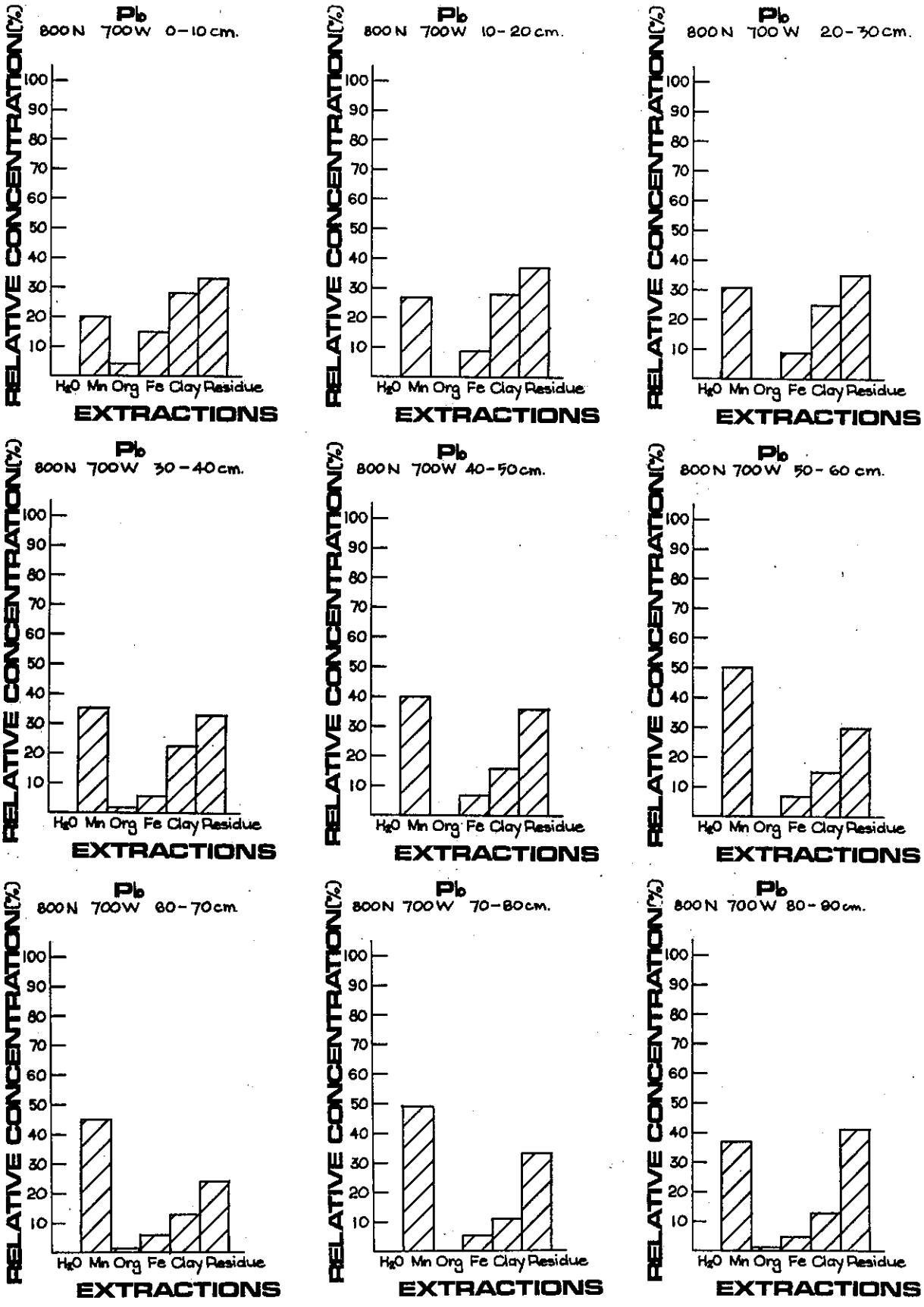


Figure: 3.82 Relative Concentration for each Extraction

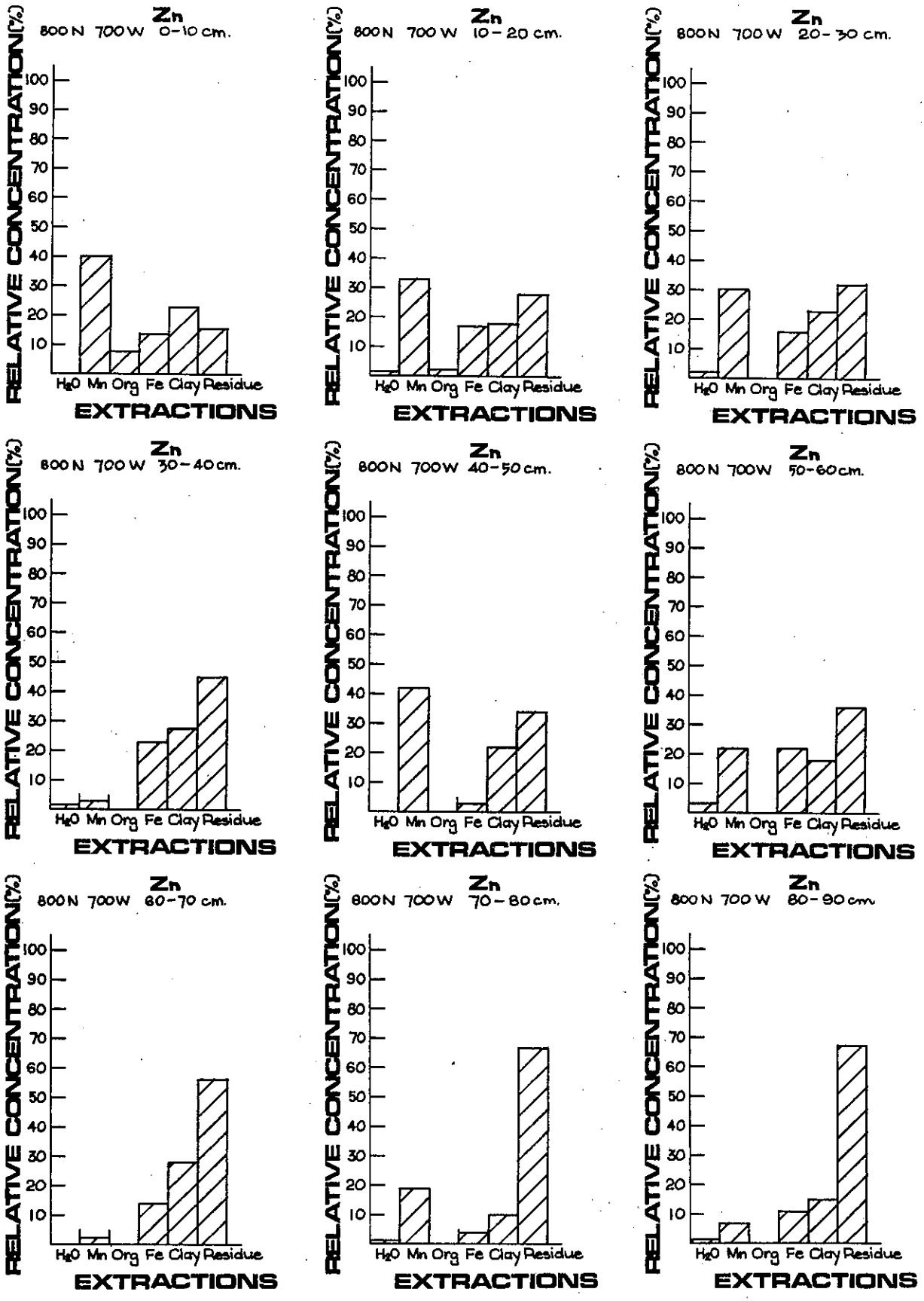


Figure: 3.83 Relative Concentration for each Extraction

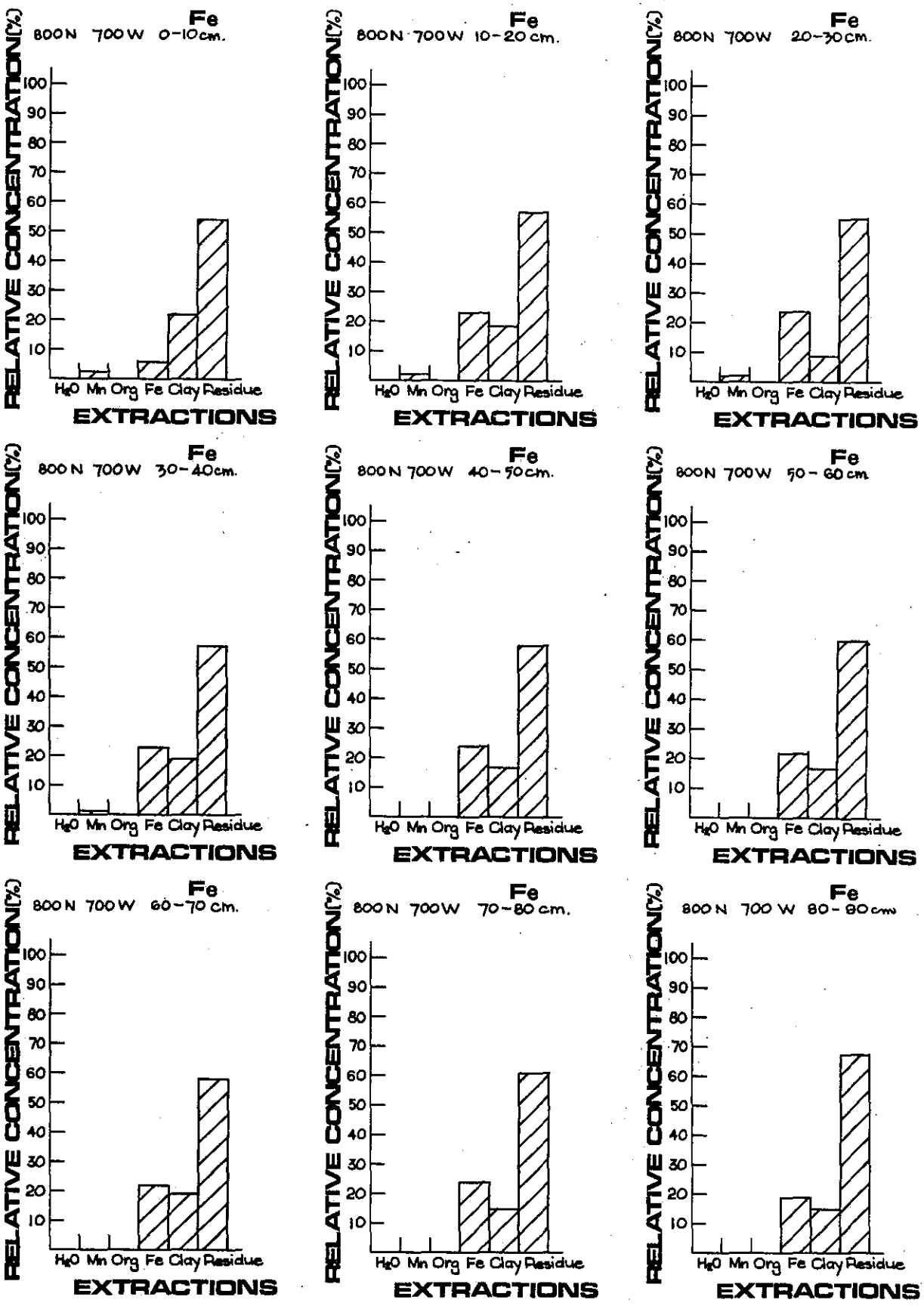


Figure: 3.84 Relative Concentration for each Extraction

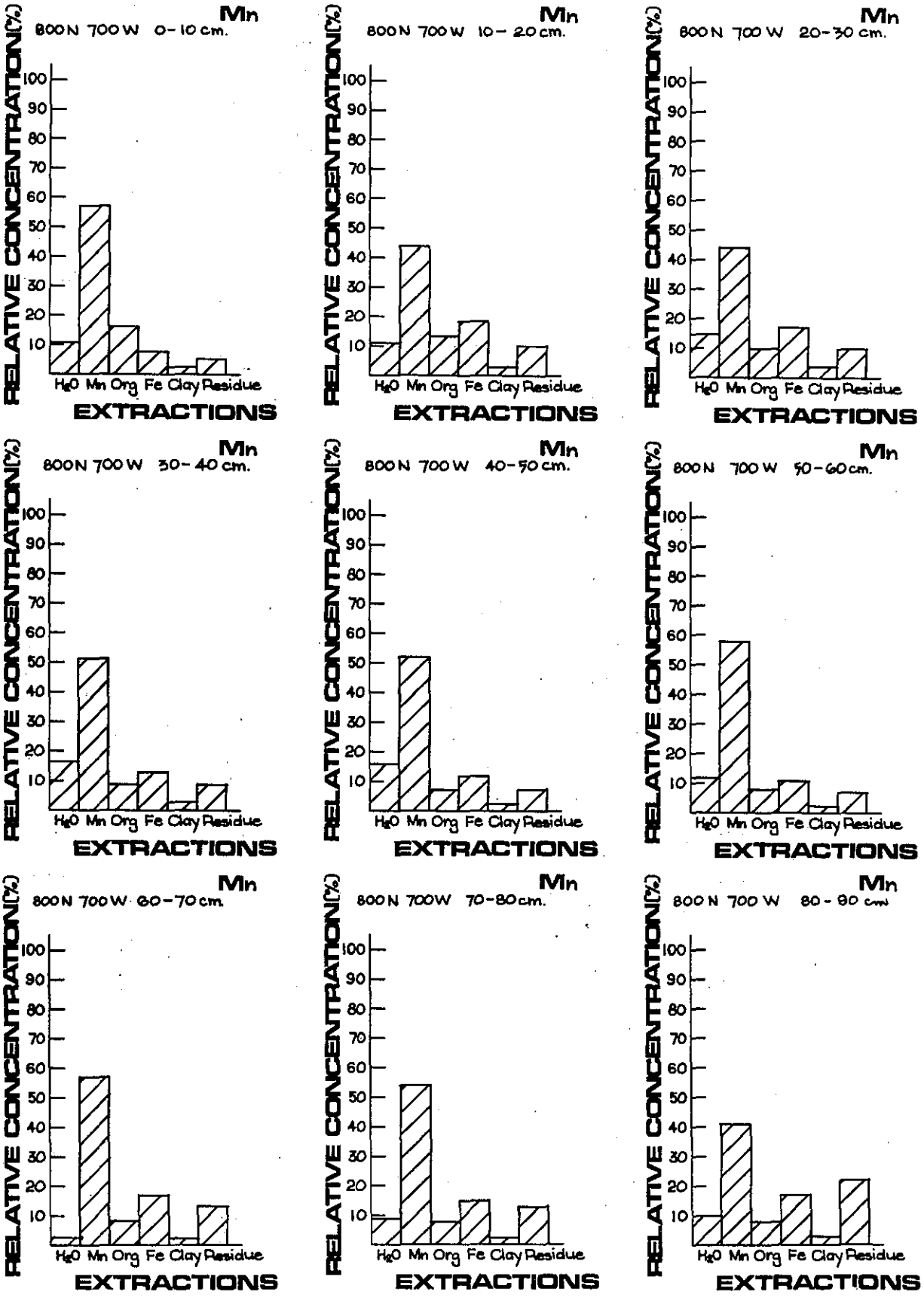


Figure: 3.85 Relative Concentration for each Extraction

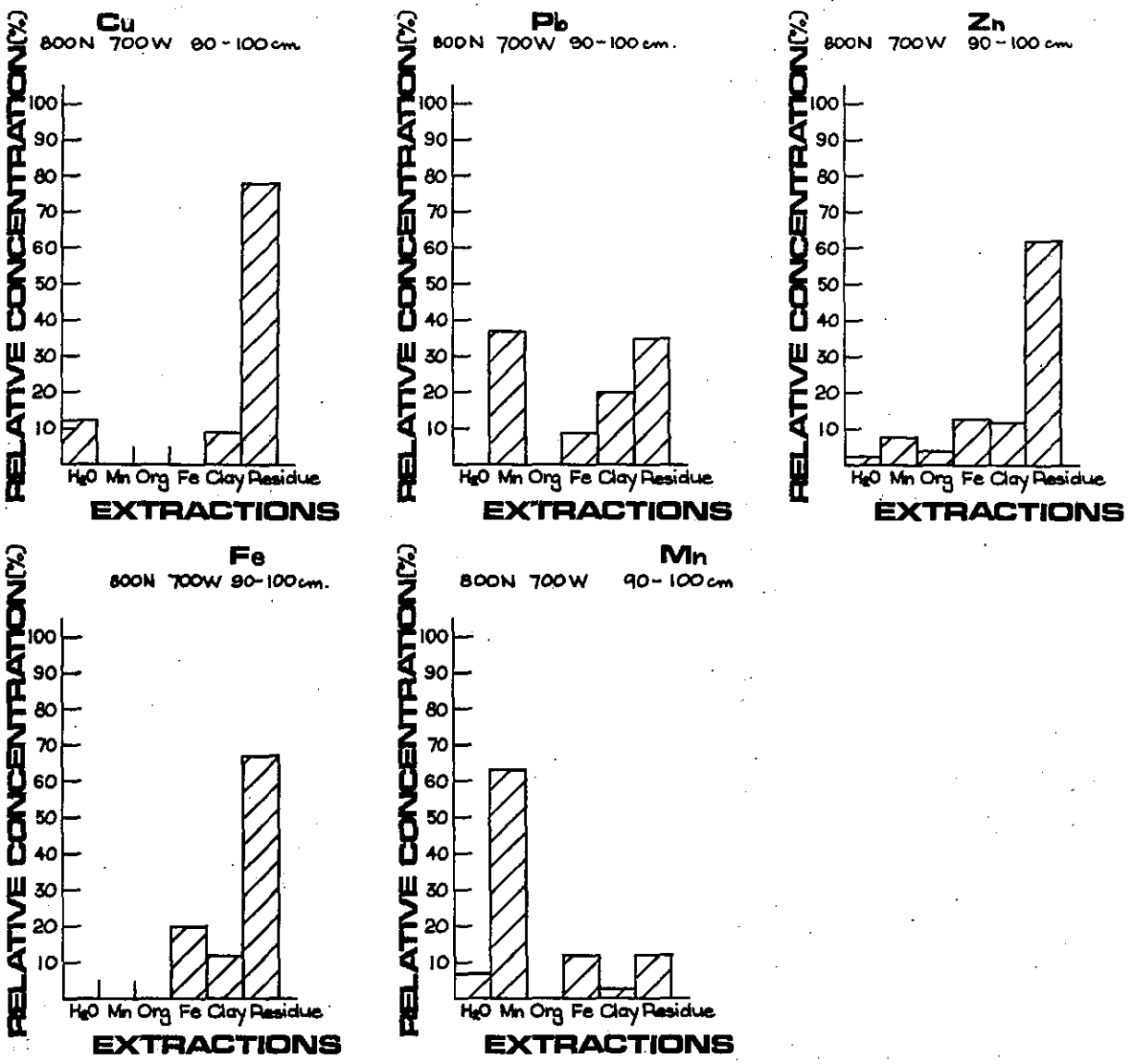


Figure: 3.86 Relative Concentration for each Extraction

3.8 PEDOGEOCHEMICAL CONCLUSIONS.

The analytical work has shown that clay is important in fixing copper and iron. Also, organic matter is highly active in sorbing iron and manganese. The two most important scavengers proved to be the oxides of iron and manganese. Finally, the "total" manganese pattern down a soil profile is very similar to the "total" iron pattern, thus suggesting a co-existence.

It has been shown that the anomaly is a combination of dispersion and seepage anomalies. In two cases (400N and 800N) it is evident that a change in lithology resulted in a change in the rate of weathering. The break-in-slope so produced, provided a seepage point for ground water. This change in slope also increased the rate of soil development. Soil and clay were worked down, off the steeper slopes to accumulate on the break-in-slope, resulting in greater soil depths. Increased weathering also deepened the soil profile which, in turn, encouraged a heavier growth of vegetation. The denser vegetation provided an increased amount of decayed organic matter and hence increased the soil organic carbon. This sudden increase of organic carbon and ground water seepage at the break-in-slope raised the soil pH and lowered the soil Eh. These conditions combined with the increased organic and clay content, resulted in the fixation of iron and manganese oxides. Then, the combination of the change in Eh - pH environment and the presence of these scavengers (Mn, Fe and clay) resulted in the fixation of copper, lead and zinc, thus producing the intense linear, lead pedogeochemical anomaly.

4. CONCLUSIONS

4.1 SUMMARY.

(i) Biogeochemical Prospecting.

Iron and lead in the ash of Nothofagus cunninghamii leaves, proved to be accurate, precise and reliable in reflecting the lead pedogeochemical anomaly at West Hercules. The clarity of the reflection was improved using suitable elemental ratios (Fe/Ni and Pb/Ni).

These results were indicated by both orientation surveys, substantiated by the detailed pilot survey and reinforced by the independent trial survey.

The litter survey produced surprisingly strong correlations between the soil-elements and litter-elements. The survey showed that a range of elements in litter, could be used to accurately reflect the horizontal distribution of soil elements. Lead in the litter unfailingly, precisely and accurately reflected the lead concentrations in the soil down five cut lines.

Hence, both Nothofagus cunninghamii and soil-litter show great promise for biogeochemical prospecting in regions similar in environment, to the West Hercules Area.

(ii) Pedogeochemical Anomaly.

The groundwater percolating from the Hercules Host Rocks upslope, contains solutions of heavy metals. When the groundwater reached a "break-in-slope", a hydromorphic anomaly was developed. A change in rock type may have caused the change in slope down 800N and 400N.

The change in slope results in deeper, more mature soils and more clay. This encourages heavier vegetation growth and subsequently greater organic material in the soils. In turn, this raises the soil-pH and lowers the soil-Eh.

This change in environment and increased organic matter causes the fixation of iron and manganese from the groundwater. Sequential analysis has indicated that clay sorbs the copper, producing the increase in soil-copper. These analyses and elemental relationships have shown that iron and manganese oxides are very active lead and zinc scavengers. Thus, both the presence of iron and manganese oxides and the change in Eh/pH environment, result in the sudden fixation of lead and zinc, producing the pedogeochemical anomaly. The increase in nickel content occurs when the Eh/pH conditions are the optimum for nickel's precipitation. As nickel is mobile, it is concentrated well down slope from the seepage.

Hence, the anomaly at West Hercules is a hydromorphic anomaly produced by groundwater seepage and dispersion from mineralized zones up slope.

4.2 FURTHER WORK.

(i) Biogeochemical Suggestions.

The strong correlation of litter-elements with soil-elements suggest that the litter aspect of biogeochemical prospecting, would be a valuable technique to fully develop and exploit. This could be done by conducting a more extensive orientation survey over an area of mineralization.

(ii) Pedogeochemical Suggestions.

The sequential extraction modified from Gatehouse (1973), is a powerful analytical tool which needs further development. The development of an extraction to distinguish between metals sorbed on clays and those incorporated within their structure, would be desirable. A weak ammonium acetate extraction could be a starting point. It would also be desirable to be able to distinguish between exchangeable and reducible manganese and iron.

Should any further exploration be conducted in the West Hercules Area, it is recommended that the possibility of mineralization at 400S 500W to 600S 500W and 600N 700W to 800N 700W be investigated.

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C O N T E N T S O F D A T A V O L U M E

PHOTOGRAPHS AND DESCRIPTION OF SOIL PROFILES.

A P P E N D I C E S

Figure: 3.3 Hole: 1600N 15W

Depth: 30 cm.

Location: (Off Anomaly)

Situated on a very steep rocky slope (≈45°), close to a very small stream. Vegetation consists of mosses and "Christmas Bells".

Description (Stoney soil, very immature)

cm	
0-1	Moss and minor litter.
1-2	Charcoal remnants of bush fire.
2-12	Grey-brown slightly organic rich layer. Organic material decreases downwards.
12-20	Light grey stony horizon.
20-30	Decomposed parent rock with some clay.
>30	Parent rock. (i.e.) Medium grained white crystal sericite tuff with brown stains.

Figure: 3.4 Hole: 1600N 200W

Depth: 1-1.12m

Location: (On anomaly)
Situated on a break of slope with thick transported soil cover. Vegetation consists of "cutting grass" and 1m high shrubs.
Soil profile consists of three buried soils, one on top of the other.

Description (mature, well differentiated)

cm	
0-2	Litter and grass.
2-5	Black to brown organic layer containing charcoal from bush fire. (Top of youngest soil)
5-10	Grey-white leached clay horizon.
10-43	Reddish-brown iron-rich clay-soil.
43-53	Whitish-brown leached clay horizon (Top of second youngest soil)

cm	
53-70	Red-brown organic and iron rich layer.
73-80	Pale brown leached clay horizon (Top of third youngest soil).
80-1m	Red-brown organic and iron rich layer.
1-1.05m	Pale brown to grey clay horizon (Top of oldest soil).
1.05-1.12m	Organic and iron rich dark brown layer.
1.12m	Decomposed parent rock (i.e.) Medium grained tuff with pyrite crystals.

Figure: 3.5 Hole: 1600N 600W

Depth 50 cm.

Location: (Off anomaly)

Situated on a moderately steep slope (≈ 30°)

Vegetation predominantly 2m high

Leptospermum nitidum (Tea Tree).

Description: (immature)

cm	
0-1	Litter.
1-35	Light brown soil with decayed organic matter.
35-50	Whitish grey soil with decomposed parent rock.
>50	Parent rock.
	(i.e.) Medium grained feldspar sericite tuff (green).

Figure: 3.6 Hole: 1600N 790W

Depth: 30 cm.

Location: (Off anomaly)
Situated on a moderate slope (≈30°), just before a steep drop down to Baker's Creek, and three metres above an old water-race. Vegetation consists of 3m high Leptospermum nitidum (Tea Tree) and "cutting grass".

Description: (immature).

cm	
0-1	Litter.
1-20	Dark grey layer becoming light grey and clay rich with depth.
20-30	Whitish grey clay rich layer.
>30	Parent rock. (i.e.) Medium grained green sericite crystal tuff with "rosette structure".

Figure: 5.7 Hole: 800N 00W

Depth: 40 cm.

Location: (Off anomaly).
Situated just below a slight break in slope with 10-15° slope. Vegetation consists of 60 cm high shrubs.

Description: (very immature, no differentiation).

cm	
0-1	Litter.
1-20	Dark brown horizon decreasing organic content with depth.
20-40	Decomposed parent rock with minor light grey clay.
>40	Parent Rock. (i.e.) Fine grained white crystal tuff.

Figure: 3.8 Hole: 800N 200W

Depth: 25 cm.

Location: (On minor anomaly)

Situated on a steep slope just below a major outcrop of fine grained pyritic sericite tuff with carbonate "augen" some of which have been replaced by mineralization.

Vegetation consists of small shrubs and "cutting grass".

Description (immature).

cm	
0-1	Black charcoal layer from bushfire.
1-20	Dark brown organic rich soil with decreasing organic content and increasing gravel content towards the base.
20-25	Light brown soil separating decomposed light grey parent rock.
>25	Parent rock. (i.e.) Fine grained white crystal tuff.

Figure: 3.9 Hole: 800N 400W
Depth: 20 cm
Location: (Off anomaly)
Situated on a slight decrease in slope. Vegetation consists of 1m high shrubs with some "cutting grass".
Description: (very immature lithosol).

cm	
0-1	Litter.
1-10	Dark brown organic layer with decreasing organic content with depth.
10-20	Light grey decomposed parent rock with some light brown-grey soil.
>20	Parent rock. (i.e.) Fine-medium grained white crystal sericite tuff with minor brown staining

Figure: 3.10 Hole: 800N 700W

Depth: 90 cm.

Location: (On major anomaly).

Situated on a moderate slope ($\simeq 20^{\circ}$), just after a slight decrease in slope and consisting of transported soils. The hole is also on the edge of the Nothofagus rain forest.

Description: (mature, well differentiated).

cm	
0-3	Litter.
3-5	Black organic layer with minor charcoal.
5-30	Brown horizon.
30-80	Light brown clay and iron rich soil with gley patches.
80-90	Brown soil containing decomposed parent rock.
>90	Parent Rock. (i.e.) Coarse grained crystal-lithic green sericite tuff with some albitization.

Figure: 3.11 Hole: 800N 800W

Depth: 70 cm.

Location: (On major anomaly)
Situated on a steeper slope than 700W, but still within the Nothofagus rain forest.

Description: (mature)

cm	
0-2	Litter.
2-20	Dark brown organic rich horizon.
20-60	Light brown clay rich horizon.
60-70	Light brown soil with decomposed parent rock.
>70	Parent rock.

(i.e.) Coarse grained crystal-lithic green sericite tuff with albitization.

Figure: 3.12 Hole: 800N- 1000W
Depth: 60 cm.
Location: (off anomaly).
Situated under thick undergrowth on a moderate slope and within the Nothofagus rainforest.

Description (immature)

cm	
0-2	Litter.
2-15	Dark brown organic rich horizon.
15-60	Light brown clay rich soil containing floating pebbles and small boulders.
>60	Parent rock. (i.e.) Coarse grained crystal-lithic green sericite tuff with albitization.

Figure: 3.13 Hole: 400N 200E

Depth: 10 cm.

Location: (On 'contamination' anomaly).
Situated on steep slope of 30-40°with vegetation consisting of small Leptospermum nitidum (Tea Tree) trees.

Description: (very immature transported soil)

cm	
0-1	Black humic soil with charcoal from bushfire.
1-10	Dark brown horizon.
>10	Parent rock.
	(i.e.) Medium grained white (minor crystal) tuff.

Figure: 3.14 Hole: 400N 225W

Depth: 40 cm.

Location (Off anomaly)
Situated on a fairly steep slope with vegetation predominantly Leptospermum nitidum (Tea Tree) and"cutting grass", in a burnt-out forest.

Description (very immature lithosol).

cm	
0-10	Humic layer with roots of grasses and charcoal.
10-20	Beige clay-rich gritty soil.
20-30	Rocky beige clayrich soil.
30-40	Decomposed parent rock.
>40	Parent rock. (i.e. White medium grained crystal tuff.

Figure: 3.15 Hole: 400N 480W

Depth: 40 cm.

Location: (Off anomaly)
Situated on a 20° slope with vegetation consisting of young Leptospermum nitidum and "cutting grass" in a burnt out forest.

Description: (immature)

cm	
0-1	Litter.
1-5	Black organic layer containing charcoal from bushfire.
5-20	Grey-brown clay rich horizon.
20-40	Greyish gravel layer.
>40	Parent rock. (i.e.) Siliceous white medium grained crystal tuff.

Figure: 3.16 Hole: 400N 600W

Depth: 30 cm.

Location: (Off anomaly)
Situated on 30° slope about 20 metres above the edge of the Nothofagus rain forest.
Vegetation consists of large bushes of "cutting grass" and 3m high Leptospermum nitidum. The hole is located just above the major soil anomaly.

Description (very immature)

cm	
0-1	Litter.
1-12	Grey-brown horizon with minor organic material.
12-20	Gravel and decayed parent rock with minor clay.
30	Parent rock.

(i.e.) Coarse grained crystal-lithic green sericite tuff with minor albitization.

Figure: 3.17 Hole: 400N 700W

Depth: 1 metre.

Location: (On major anomaly)
Situated on a flat just inside the Nothofagus rain forest and close to an old water race.

Description (mature)

cm	
0-3	Litter.
3-27	Iron rich red-brown soil horizon.
27-80	Mottley iron stained clay horizon with some gley patches.
80-100	Gravel and decomposed parent rock with clay.
>1m.	Parent rock. (i.e.) Coarse grained crystal-lithic green sericite tuff showing albitization.

Figure: 3.18 Hole: 400N 900W

Depth: 80 cm.

Location: (On major anomaly).
Situated well within the Nothofagus rain forest on a shallow slope with evidence for transported soil.

Description (mature and differentiated).

cm	
0-2	Litter.
2-8	Grey to black organic layer.
8-23	Light grey-brown humic clay
23-27	Light brown-yellow mottled clay with iron staining.
27-62	Gravelly clay with reddish-brown iron staining and some gley patches.
62-80	Yellow-grey gritty clay with pebble layer.
>80	Parent rock. (i.e.) Crystal lithic tuff.

Figure: 3.19 Hole: 400N 1125W

Depth: 50 cm.

Location: (Off anomaly)
Situated on a break of slope within the Nothofagus rain forest, below the major soil anomaly.

Description: (moderately mature).

cm	
0-3	Litter.
3-14	Brown organic rich horizon.
14-22	Light yellowish-brown clay rich layer.
22-50	Mottled yellow-brown clay layer with gley patches, iron staining and pebble bands.
>50	Parent rock. (i.e.) Medium grained crystal-lithic grey tuff.

Figure: 3.20 Hole: 400N 1300W

Depth: 50 cm.

Location: (Off anomaly)
Situated on a moderate slope well within the Nothofagus rain forest, below the major soil anomaly.

Description: (moderately mature)

cm	
0-5	Litter.
5-25	Organic rich grey-brown horizon.
25-40	Grey-brown clay rich soil.
40-50	Yellowish-brown clay rich horizon with gley patches and iron staining.
>50	Parent rock. (i.e.) Grey-black shale (?)

Figure: 3.21 Hole: 300N 500E

Depth: 50 cm.

Location: (On 'contamination' anomaly).
Situated on a break of slope within a burnt out forest with predominant Leptospermum nitidum vegetation.

Description (moderately mature transported soil).

cm	
0-1	Organic layer.
1-12	Very humus rich black-brown soil horizon.
12-30	Dark brown organic rich soil layer.
30-50	Brown rocky soil with decomposed parent rock.
>50	Parent rock.
	(i.e.) Medium grained white crystal tuff.

Figure: 3.22 Hole: 800S 200E

Depth: 40 cm.

Location: (On minor anomaly)
Situated on a slight break of slope within the Nothofagus rain forest and above the major soil anomaly.

Description: (immature)

cm	
0-2	Litter.
2-8	Dark brown organic rich layer.
8-23	Light brown iron and clay rich layer.
23-40	Decomposed parent rock with light brown iron rich soil.
>40	Parent rock. (i.e.) Coarse green sericite crystal tuff with albitization.

Figure: 5.23 Hole: 800S 00W

Depth: 80 cm.

Location: (On minor anomaly)
Situated on a steep slope (≈45°) close to a scree slope within the Nothofagus rain forest but above the main soil anomaly.

Description (moderately mature)

cm	
0-1	Litter.
1-10	Dark brown organic rich soil.
10-30	Grey-brown pebbly layer with gley patches in clay.
30-80	Reddish brown iron and clay rich soil with some floating pebbles.
>80	Parent rock. (i.e.) Coarse green sericite crystal tuff showing albitization.

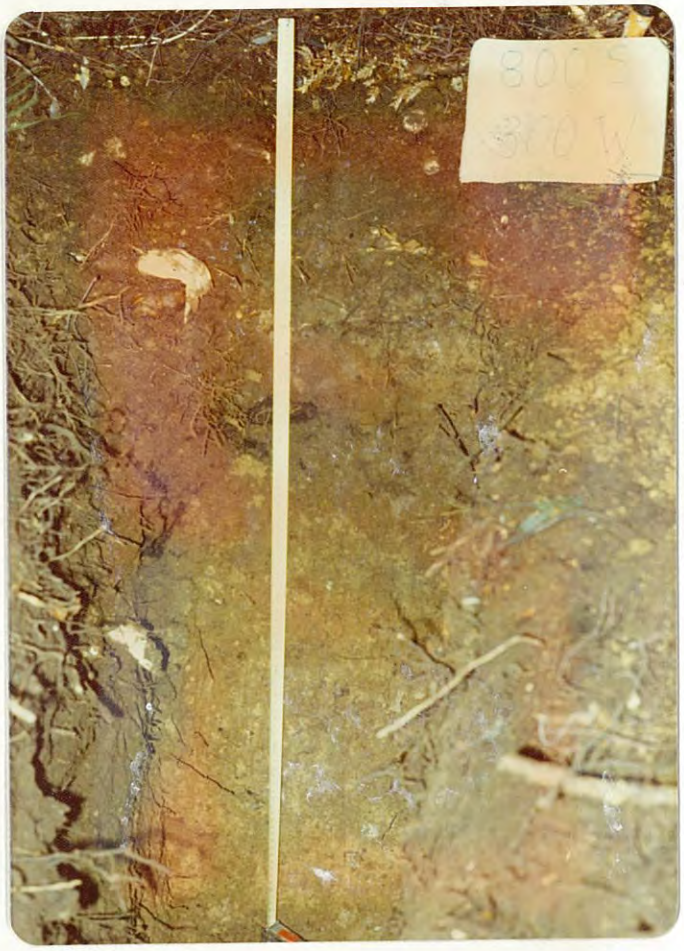

Figure: 3.24 Hole: 800S 300W

Depth: 1.3 metres.

Location: (on major anomaly)
Situated on a break in slope within the Nothofagus rain forest and just inside the major soil anomaly.

Description: (mature)

cm	
0-10	Litter.
10-20	Manganese and organic rich dark brown soil.
20-55	Dark brown soil containing gravel.
55-90	Yellowish clay rich soil with mottley yellow patches.
90-100	Pebble layer with yellowish soil.
100-130	Yellow-brown clay with grit and decomposed parent rock.
>1.30m.	Parent rock. (i.e.) Coarse green sericite crystal tuff showing albitization.

Figure: 3.25 Hole: 800S 400W

Depth: 1.3 metres.

Location: (On major anomaly)
Situated on a break of slope well within the Nothofagus rain forest. At least two buried soils are evident, indicating that the profile owes its depth to soils washed down off the steeper slopes above.

Description (Mature and well differentiated).

cm	
0-1	Litter.
1-50	Dark brown organic rich layer (Top of youngest soil)
50-80	Light brown "B" horizon of youngest soil.
80-110	Light brown iron rich organic "A" horizon of buried soil.
110-130	Light brown clay rich soil with pebbles.
>130	Parent rock (probably transported) (i.e.) White fine grained tuff with minor light green sericite and some iron staining.

Figure: 5.26 Hole: 2400S 500E

Depth: 20 cm.

Location (Off anomaly)
Situated on a shallow slope of 10-15° with 'alpine type" vegetation consisting of grass tufts and bushy Leptospermum nitidum.

Description: (very immature).

cm	
0-1	Moss and litter.
1-20	Light brown, undifferentiated soil with chips of parent rock.
>20	Parent rock. (i.e.) Medium grained white-grey crystal tuff with some fiamme (?)

Figure: 3.27 Hole: 2400S 180E

Depth: 30 cm.

Location: (Off anomaly)
Situated on a steep slope within the Nothofagus rain forest and just above the major soil anomaly.

Description: (very immature lithosol)

cm	
0-2	Litter.
2-10	Dark brown humic layer.
10-30	Pale grey clay rich soil with occasional brown iron spots.
>30	Parent rock (i.e.) Coarse grained green sericite crystal-lithic tuff with albitization.

Figure: 3.28 Hole: 2400S 200W

Depth: 50 cm.

Location: (On major anomaly)
Situated on a steep slope (≈45°) just below ridge crest on edge of a burnt out forest. Vegetation consists of thick bushes of "cutting grass" with some Leptospermum nitidum.

Description: (moderately mature)

cm	
0-3	Litter.
3-6	Humus rich soil, could almost be described as peaty.
6-25	Beige coloured clay and iron rich soil.
25-50	Mottled beige coloured clay and iron rich soil with grey gley patches and yellow iron staining.
>50	Parent rock. (i.e.) Grey-black shales (inter bedded with tuffs as a lens-?)

Figure: 3.29 Hole: 2425S 250W

Depth 30 cm.

Location: (On major anomaly)
Situated on the crest of a spur with a slope of approximately 20° and in predominantly "cutting grass" vegetation. The hole is in a burnt-out pine (?) forest very close to old mine workings in viened quartz.

Description: (moderately mature)

cm	
0-2	Litter.
2-5	Grey-brown organic horizon.
5-10	Leached horizon with minor mottled patches.
10-20	Gleyed clay rich horizon with yellow iron stainings.
20-30	Iron rich gleyed brown clay with fragments or parent rock.
>30	Parent rock (i.e.) Grey-black shale (interbedded with tuffs as a sedimentary lens ?)

Figure: 3.30 Hole: 2400S 350W

Depth: 60 cm.

Location (Off anomaly)

Situated on a slight break of slope on the side of a spur within a burnt-out forest

Vegetation consists of ferns and "cutting grass".

Description (moderately mature)

cm	
0-5	Litter.
5-15	Light brown organic rich layer.
15-25	Light brown clay rich soil.
25-35	Fragments of parent material and grit incorporated within light brown soil.
35-60	Increased amounts of light grey parent material and clay.
>60	Parent rock. (i.e.) Fine grained grey crystal tuff.

Figure: 3.31 Hole: 2400S 520W

Depth: 90 cm.

Location: (Off anomaly)
Situated just before the start of the Nothofagus rain forest on a moderately steep slope.
Vegetation consists of large clumps of "cutting grass" and Leptospermum nitidum.

Description (mature)

cm	
0-5	Litter.
5-40	Light brown organic rich soil.
40-50	Iron rich horizon with patches of iron staining.
50-65	Strongly developed gley horizon with yellow iron stains
65-90	Grey clay horizon with some iron staining and fragments of parent rock.
>90	Parent rock. (i.e.) Coarse grained green sericite crystal-lithic tuff with albitization.

Figure: 3.32 Hole: 100 ft. from open cut at Murchison Mine.

Location: Situated on flat ground close to Nothofagus rain forest and not dug to bed rock. Soil possibly shifted recently as there was no profile differentiation.

Description (very immature)

cm	
0-3	Litter.
3-5	Weak organic horizon of darkish-brown soil.
5-40+	Light brown undifferentiated sandy soil. (Not dug to bed rock)

A P P E N D I X A.1

PREPARATION OF VEGETATION SAMPLES FOR ANALYSIS

1. SAMPLE COLLECTING.

(1.1) Approximately 100 g of fresh vegetation needs to be collected, as this will produce the 10-30 g of dried material required for ashing prior to sample digestion. The samples should be removed from the trees with pruning shears or secateurs.

(1.2) The vegetation can then be placed directly into strong plastic bags (approximately 20 cm x 35 cm) and sealed with aluminium wire and tags. Samples should be taken at various points around the circumference of the tree or shrub, as high up as can be conveniently reached.

(1.3) Leaves will only keep fresh for one week in plastic bags and hence must be dried within a week of sampling. They should be stored in a shady, cool place. Twigs, of course, will keep much longer than leaves.

2. SAMPLE PREPARATION.

(2.1) Drying: Back in the laboratory, when the vegetation is removed from the plastic bags, it should be washed vigorously under running water and then thoroughly rinsed in distilled water and shaken dry. This serves to remove any dust or soil that would cause contamination problems.

(2.2) The samples should then be spread on previously folded aluminium-foil trays (20 x 30 x 3 cm). Any twigs or wood should be cut up into small segments before the drying process, as once the material is dry it is very much harder to cut. Any splitting of twigs or separation of bark should also be done at this stage.

(2.3) The vegetation can then be dried in a large

oven at 90-100°C for 2 days (or until dry). The samples could be dried over night at 110°C but extreme care should be taken to ensure that charing and subsequent ignition of the other samples (and the oven!) does not occur. If time and oven space permit, the longer drying procedure should be followed. Avoid use of drying ovens with exposed elements and do not use oven fans.

(2.4) Once dried, the samples will keep for much longer without deterioration. They can be sealed in plastic bags and stored in a dry, dark, cool place.

(2.5) Grinding: In order to obtain a representative sample for analysis, the dried samples must be crushed to a fine powers (< 1 mm) and mixed. If leaves and twigs are to be analysed separately, they should be separated after the drying process and prior to crushing.

(2.6) The most efficient method of powdering the dried leaves, small twigs or bark is to use the high-speed rotary "Casella" wheat-grinder (Figure 2.7). With this machine, 30 g leaf samples can be ground to a fine powder within 30 seconds. The grinding time for bark samples is slightly longer. Finely split wood and larger twigs can be ground in a similar manner, but the procedure is tedious and can cause irrepairable damage to the grinder.

(2.7) Once powdered, the individual samples can be mixed and stored in small labelled sample bags. Between 10 g and 30 g of powdered samples is required for the next step of dry ashing.

(2.8) Dry Ashing: Ten grams of dried vegetation will produce about 0.2 g. of ash from woody material and 0.6 g. of ash from leaves. So between 20 g and 15 g of ground

material is needed for ashing. This should be placed in 50 ml squat 'Pyrex' beakers and ashed in a muffle furnace. The ashing should be done at 375°C for 8-10 hours and if further ashing is needed, the muffle furnace can be left at 450°C for a further 12 hours. Little loss of volatile elements occurs below 450°C (Arsenic being one notable exception), but at higher temperatures (500°C) there is a very real risk of losing such volatile components as lead and cadmium.

Ashing should be conducted in the presence of air. If too much air is admitted, the material will catch fire. Insufficient air can cause the volatilization of some constituents. (Brooks, 1972).

(2.9) When the samples have been completely ashed (i.e. when no free carbon remains) and have cooled down, they can be stored in self-sealing paper "pay envelopes".

3. SAMPLE DIGESTION. (Outline of Australian Laboratory Services' procedure).

(3.1) The optimum weight of plant ash required for the digestion is 0.5 g. This should be digested with 20 mls of 10% HCl for one hour at a temperature of 180°C.

(3.2) The samples can then be shaken thoroughly and allowed to settle.

(3.3) The supernatant liquid should then be carefully decanted into labelled containers, ready for analysis by atomic absorption spectrometry.

A P P E N D I X A.2

PREPARATION OF SOIL SAMPLES FOR ANALYSIS

1. SAMPLE COLLECTING.

(1.1) Approximately 500 g of soil needs to be collected as this will be the optimum sample size with regard to weight and representation of the sampled horizon.

(1.2) The samples should be placed in strengthened paper sample bags and labelled. Any large fragments of parent rock should be removed by hand prior to the sealing of the sample bags.

(1.3) It is unwise to store the samples for long in this condition. If they are packed together and not air dried, the paper sample bags will rot and disintergrate. If the samples are air dried in the sample bags, the soil will dry into hard clods (a particular problem in clay rich soils) which prove difficult to break up.

2. SAMPLE PREPARATION.

(2.1) Drying: Back in the laboratory the soil samples should be removed from their paper bags and spread to dry on flat trays (50 x 60 x 2.5m) made from wood, galvanized iron, fiberglass or plastic.

(2.2) It is most important to maintain the identity of each sample at all stages of preparation.

(2.3) The samples can then be allowed to dry in the air over a period of several days. The trays should be placed on racks in either a special drying room or cabinet with circulating warm air. The relative humidity should be between 30% and 70% and the temperature should not be allowed to exceed 35^{o}C.

(2.4) The procedure for drying soils should be standardized as far as possible, as the degree to which chemical and physical changes occur within soils varies with the temperature and time of drying.

(2.5) Grinding and Sieving: After the soil has been air-dried, the stones and pieces of macro-organic matter should be picked out.

(2.6) Large lumps of soil can be broken up by hand and then the soil ground by rolling gently with a wooden roller. This can be done either by hand or mechanically. Mechanical grinders, with rotating wooden or hardened steel rollers mounted above a 2mm sieve, reduce the tediousness of the task.

(2.7) The most efficient method of further grinding the soil is to use the high speed rotary "Hobart Cadet" soil grinder (Figure 3.33). With this machine, 500 g soil samples can be reduced to approximately 1mm grain-size within 45 seconds.

(2.8) At this stage, the soil is sufficiently finely ground for chemical digestion and analysis. However, some analytical techniques (e.g. X.R.F.) require a finer powder which can be obtained using a rotary mill.

(2.9) After grinding the soil can be stored in labelled, strengthened paper or plastic sample bags in a dry, dark, cool place.

3. SAMPLE DIGESTION.

The technique of "Sequential Analysis" of soils is covered elsewhere in this appendix (Page 108). The following is an outline of the methods of sample digestion used by Australian Laboratory Services for both rocks and soils.

(3.1) For the elements Cu, Pb, Zn, Ni, and Cd, the samples can be digested with 70% $HClO_4$, diluted and analysed by A.A.S.

(3.2) For the elements Fe and Mn, the samples can be digested with conc. HCl , diluted and analysed by A.A.S.

(3.3) For barium, the samples should be digested with HCl and $HClO_4$, diluted and analysed by A.A.S. with interference supressant added.

A P P E N D I X B.1

ANALYTICAL PROCEDURES USED FOR THE SEQUENTIAL ANALYSIS OF SOILS. (Modified from Gatehouse, 1973).

1. REAGENTS.

Ammonium Acetate Solution: 162 grams of A.R. Ammonium Acetate, (CH_3COONH_4) were added to 1.8 litres of distilled water and brought to a pH of 4.5 by the addition of A.R. concentrated Acetic Acid, (CH_3COOH). The solution was made up to 2 litres with distilled water.

Hydrogen Peroxide: A.R. Hydrogen Peroxide, (H_2O_2), 130 volumes.

Ethanol: 95% Ethanol, (C_2H_5OH).

Hydrazine Chloride Solution: 50 mls of 99% Hydrazine Hydrate, N_2H_5OH, were added to 0.9 litres of distilled water. This was brought to a pH of 4 with A.R. concentrated Hydrochloric Acid, (Approximately 150 ml HCl), prior to further dilution to 1 litre with distilled water.

0.01 M Nitric Acid: 0.63 ml was made up to 1 litre.

Perchloric Acid: 70% A.R. Perchloric Acid, ($HClO_4$).

Hydrochloric Acid (dilute): 5 millilitres of concentrated Hydrochloric Acid, (HCl), specific gravity 1.16, were diluted with distilled water to 100 millilitres.

0.1M Acidified Hydroxylamine Hydrochloride Solution: 6.95 g of Hydroxylamine Hydrochloride ($NH_2OH.HCl$) were made up to 1 litre with 0.01 M nitric acid (pH2).

2. APPARATUS.

Test tubes: 115 x 24 millimetre medium walled glass pyrex test tubes fitted with silicon rubber stoppers. These test tubes are made from 200 mm long test tubes, cut off to exactly the same weight.

Automatic Pipettes: adjustable 30, 20 and 2 millilitre automatic dispensing zipettes with 2, 2 and 1 litre solution storage respectively.

Volumetric Flasks: 200, 100 and 50 millilitre capacities.

Polythene Bottles: 100 and 50 millilitre capacities.

Shaking Apparatus: Horizontal mechanical shaker.

Centrifuge: International Equipment Company, Number K_2 centrifuge fitted with a 16 sample 240 head.

Mixer: Fisons Ltd., Whirlmixer, reference WM.

Hot-plate: Scientific Equipment Manufacturers 460 x 260 millimetre hot plate with a temperature range up to 250°C.

Aluminium Heating Block: 300 x 225 x 50 millimetre block of cast aluminium drilled to a depth of 40 millimetres with 50, 26 millimetre diameter holes.

Atomic Absorption Spectrometer: a Varian Techtron Type AA-3 Atomic Absorption Spectrometer fitted with:

(i) A Techtron Type AB41 long path air-acetylene burner.

(ii) Varian-Techtron hollow cathode zinc, lead, copper and combined cobalt-manganese and iron-chromium lamps.

3. STANDARDS.

Primary Standards.

10,000 ppm iron solution

70.21 grams of A.R. ferrous ammonium sulphate, $[Fe(NH_4)_2(SO_4).6H_2O]$, were dissolved in acidified distilled water and made up to 1 litre in a volumetric flask prior to storage in a polythene bottle.

1,000 ppm copper-lead-zinc-manganese solution

1 gram of A.R. copper foil, (Cu), dissolved in nitric acid, 1 gram of A.R. zinc oxide (ZnO), dissolved in hydrochloric acid, 1.60 grams of A.R. Lead nitrate, ($PbNO_3$) and 1 gram of A.R. manganese metal powder (Mn) were all dissolved in minimum nitric acid and diluted with distilled water to 1 litre in a volumetric flask. The solution was stored in a glass bottle.

3.1 STANDARDS FOR DISTILLED WATER EXTRACTION.

Standards were made to span 1, 2, 5, 10 to 100 ppm iron concentrations in the solutions. These were prepared by successive dilution of the 10,000 ppm primary standard noting that 1 ppm in solution was equivalent to ≈67 ppm in the soil. (The dilution factor for the ammonium acetate extraction was about 66•67 to 1 as approximately 1.5 grams of soil were extracted into 100 millilitres of solution. [(i.e.) Actual soil concentration = solution concentration x $\frac{\text{Volume of Solution}}{\text{Weight of sample of soil}}$.]

Copper-lead-zinc-manganese standards were made by similar dilution of the 1000 ppm primary standard. These covered the range 1, 5, 10 etc. ppm to 1 % metal in soils. Where the iron was below the interference level it was unnecessary to match the iron contents of the Cu-Pb-Zn-Mn standards to those in the extracted soil solutions.

All standards were stored in polythene bottles, except the lead standards which were stored in glass.

3.2 STANDARDS FOR THE ACIDIFIED HYDROXYLAMINE HYDROCHLORIDE EXTRACTIONS.

The standards for this extraction were made in a similar manner to the distilled water standards (3.1) However, these contained 60 millilitres of hydroxylamine hydrochloride solution per 100 millilitres of final solution.

3.3 STANDARDS FOR HYDROGEN PEROXIDE EXTRACTION.

These standards were made in a similar manner to the distilled water standards (3.1). These, however contained 15 millilitres of ammonium acetate solution in 100 millilitres of standard solution.

3.4 STANDARDS FOR THE HYDRAZINE EXTRACTION.

Standards for the hydrazine extraction were made in a similar manner to the distilled water standards. These however contained 10 millilitres of hydrazine solution as well as 15 millilitres of ammonium acetate reagent per 100 millilitres of standard solution. The concentrations covered were :

100 ppm to 10% iron in soil

0.5 ppm to 1% copper-lead-zinc-manganese in soil.

Due to interference, the iron content of the copper-lead-zinc-manganese standards were matched to soil extracts containing over 200 ppm iron in solution. This was done by making three duplicate series of standards as above but containing approximately 200 ppm, 500 ppm, and 1000 ppm iron in solution. The lead standards were stored in glass flasks.

3.5 STANDARDS FOR THE PERCHLORIC ACID EXTRACTIONS.

Standards for the perchloric acid extractions were made up in 20 millilitres of perchloric acid, 5 mls of concentrated hydrochloric acid and diluted to 100 mls. These were made from the primary standards to span soil concentrations of:

iron, 10 ppm to 10,000 ppm.

copper-lead-zinc-manganese, 0.1 ppm to 0.1%.

The dilution factor was 1 ppm in solution equalled 33.33 ppm in soil.

Duplicate copper-lead-zinc-manganese standards were prepared with 500 and 1000 ppm iron in solution to allow for interference effects in high iron samples.

4. EXTRACTION PROCEDURES

(4.1) Extraction with Distilled Water (M-H_2O).

(a) Approximately 1½ grams of each soil sample were weighed accurately and placed in pyrex test tubes fitted with silicon rubber stoppers.

(b) 10 millilitres of distilled water (buffered to soil pH) were added to each, the test tubes stoppered, mixed and shaken for 20 minutes.

(c) After balancing with distilled water, the samples were centrifuged for 30 minutes at 2500 RPM.

(Note:- the rubber stoppers must be removed before centrifuge starts!)

(d) The supernatant solutions were transferred with care to 100 millilitre volumetric flasks.

(e) Steps, b, c, and d were repeated twice.

(f) The sum of the supernatants were made up to 100 millilitres in the volumetric flask.

(g) Floating organic matter was filtered off using "Millipore" vacuum filter apparatus.

(h) Solutions, with appropriate standards were aspirated into the atomic absorption spectrometer.

(i) The residues in the test tubes were treated by procedure 4.2.

(4.2) Extraction with Acidified Hydroxylamine Hydrochloride (M-Mn). (Modified from Chao, 1972).

(a) Twenty-five (25) millilitres of acidified hydroxylamine hydrochloride was added to each sample.

(b) The test tubes were stoppered, mixed and then shaken for 20 minutes.

(c) After balancing with acidified distilled water, the samples were centrifuged for 30 minutes at 2500 RPM.

(d) The supernatant solutions were transferred with care to 100 millilitre volumetric flasks.

(e) Steps (a) to (d) were repeated twice.

(f) The sum of the supernatants were made up to 100 millilitres in the volumetric flask.

(g) Floating organic matter was filtered off using "Millipore" vacuum filter apparatus.

(h) The solutions with appropriate standards were aspirated into the atomic absorption spectrometer.

(i) The residues in the test tubes were treated by procedure 4.3.

(4.3) Extraction with Hydrogen Peroxide (M-Organic) (Jackson, 1956)

(a) To each sample were added 4 drops of 100 volume

hydrogen peroxide. The initial reaction was watched carefully so that frothing over did not occur. If this was imminent it was prevented by adding a few drops of ethanol.

(b) The samples were heated cautiously on an aluminium block set at 60°C until the initial reaction had ceased.

(c) Then 0.5 ml of hydrogen peroxide was added repeatedly and periodically stirred until no visible reaction or organic matter remained. This procedure took between 8 and 12 hours.

(d) 5 millilitres of hydrogen peroxide were added to the solutions and left over night. They were then mixed and heated to 80°C until all the hydrogen peroxide was destroyed. (approximately 10 minutes)

(e) 10 millilitres of ammonium acetate solution was added. The solution was mixed on the whirli-mixer and shaken for 20 minutes.

(f) The test tubes were balanced with acidified distilled water and centrifuged for 30 minutes at 2500 RPM.

(g) The supernatants were decanted into 100 millilitre volumetric flasks.

(h) Steps (e) to (g) were repeated two times.

(i) The volumetric flasks were made up to 100 millilitres and the contents were filtered through a "Millipore" vacuum filter.

(j) The solutions with standards were aspirated into the atomic absorption spectrometer.

(k) The residues were treated by procedure 4.4

4.4 Extraction with Hydrazine Solution (M-Fe).(Gatehouse 1973

(a) 10 millilitres of hydrazine chloride solution were

added to the residues in each test tube. These were heated to 90°C on an aluminium block, in a fume cupboard. Periodic mixing gave faster reactions.

(b) Two more 10 millilitre samples of hydrazine chloride solution were added. This reaction took 24 hours to complete.

(c) After the reaction had ceased the residues were invariably bleached. An extra 10 millilitres of hydrazine solution was added to each and the samples heated to ensure complete reaction.

(d) Steps (e) to (i) of procedure 4.5 were followed.

(e) The resulting solutions were aspirated initially for iron. The estimate of the iron contents of the solutions thus gained enabled selection of appropriate standards for the measurement of copper, lead, zinc and manganese concentrations.

(f) The residues were treated by procedure 4.5.

4.5 Centrifugation for Clay and Silt Fractions.(Jackson 1956)

(a) The residues from 4.4 were filled to a depth of approximately 4 centimetres with distilled water and mixed.

(b) They were then filled to a depth of 10 centimetres and placed in the centrifuge.

(c) The centrifuge was brought to 750 RPM as quickly as possible (25 seconds). It was important that the time lapse between suspension and starting of centrifugation was kept at a minimum. This speed was maintained for 5 minutes 20 seconds after which the centrifuge was stopped as quickly as possible (35 seconds).

(d) The remaining suspensions were acidified with 3 to 4 drops of dilute hydrochloric acid, into appropriately

numbered test tubes and centrifuged at 2500 RPM for 30 minutes. The supernatants were discarded.

(e) The above steps were repeated 5 times, and by then the suspensions had become only slightly turbid.

(f) The resulting clay and silt fractions were air dried and weighed.

4.6 Perchloric Acid Extraction of Clay and Silt Residues (M-Clay and M-Residue).

(a) 10 millilitres of perchloric acid were added to each of the silt and clay residues. These were heated, with periodic mixing, at 200°C for 2 hours in a fume cupboard.

(b) After cooling the samples were centrifuged (10 minutes at 2500 RPM ≈ 50 mark on Centrifuge scale) and the supernatants transferred to 50 millilitre volumetric flasks.

(c) Three washings with 10 millilitres of dilute (1:10) hydrochloric acid and one washing with 10 millilitres of acidified distilled water was followed each time by complete mixing with the whirlmixer, subsequent centrifugation and decanting of the supernatants into the 50 millilitre volumetric flasks.

(d) After the final washing the residues were discarded and the solutions made to 50 millilitres with distilled water prior to being transferred to polythene bottles.

(e) The aspiration procedure was the same as in procedure 4.4, step (e). The third and fourth most sensitive wave lengths for iron were used with crossed burners for concentration spans of 10-100 ppm Fe and 100-1000 ppm Fe.

A P P E N D I X B.2

DETERMINATION OF CARBON IN SOILS BY DRY COMBUSTION

1. SAMPLE PREPARATION.

(1.1) The sample must be ground to a fine powder, (oven dried if necessary), and a maximum of 1 g used. The optimum amount required will vary depending on the sample material, from 0.1 g (for Carbon-rich material) to 1 g. If the material is carbon-rich and too much is used per sample, the CO_2 produced will result in an off-scale reading. Or at worst, violent explosions can occur inside the combustion tube and inside the Cr_2O_3/H_2SO_4 gas-scrubber of the purifying train. Consequently it is wise to start with 0.1 g samples.

(1.2) It is often advisable to mix aluminimum oxide powder (Al_2O_3) with the sample in a sample to Al_2O_3 ratio of 1:2. This serves to 'open up' the fabric of the sample and prevents any hard crust forming. As such, the Al_2O_3 ensured complete combustion of the carbon in the sample. Soil samples should be mixed in a ratio of 1 part soil to 2 parts Al_2O_3 powder. Samples high in iron tend to form excessive slag and must also be mixed with Al_2O_3 or preignited alundum powder. The Al_2O_3 should be fired prior to use in a similar manner to the porcelain boats. Both the Al_2O_3 and the porcelain boats should either be kept in a dessicator or an oven ($\geq 110^{\circ}C$) after they have been fired.

(1.3) Each sample should be tested for the presence of carbonate (with 4N HCl) as this method does not distinguish between carbonate-carbon and organic-carbon. The results produced are indicative of the

total carbon in the sample. For carbonate removal see Grossman and Millet (1961), Jackson (1956) and Van Moort and de Vries (1970).

2. COMBUSTION OF THE SAMPLE.

The correct procedure for operation of the Ströhlein apparatus (Figures 3.38-4.42) is as follows:

(2.1) The burette should be allowed to equilibrate. (i) The burette bulb must be full of liquid (water). This is achieved by opening the lower stopcock F_4 (3 way) to the atmosphere and raising the levelling bottle to maximum height ($\top$ position). (ii) The KOH trap levels must be equal. This is achieved by turning the upper stopcock "H" to connect the absorption train to the atmosphere (lower stopcock open to atmosphere). After the levels equilibrate the upper stopcock is turned to connect burette and lower stopcock.

(2.2) The furnace and lines to lower stopcock F_4 must be flushed for 30 seconds with oxygen. Stopcock F_4 must be open to the air, closed to the burette but open to the furnace and gas bottle A. (Stopcock position $\vdash$.)

(2.3) Initially several oxygen 'blanks' must be put through the system. This ensured that no CO_2 from the air is present in any section of the apparatus. The second or third 'blank' should give a zero absorption reading. A persistant positive reading on blanks is indicative of a leak in the system.

(2.4) As a check of accuracy, it is useful to run a 'blank' using an empty boat containing Al_2O_3. This can also be used as a check for leaks in the system (see below under 5:- Detection of leaks).

(2.5) After flushing for about 30 seconds, the stopcock F_4 is closed completely (position Y) and a slight build-up of oxygen allowed in the combustion tube.

(2.6) The following must take place in rapid sequence in order to prevent CO_2 contamination from the air (i) The silicon-rubber stopper is removed from the end of the combustion tube. (ii) The plunger is used to push the boat quickly down to the hottest part of the tube. (iii) The furnace stopper is then firmly replaced after the plunger has been withdrawn.

(2.7) This is followed by the introduction of more oxygen into the furnace. The charge should be just sufficient to start bubbling in the Cr_2O_3/H_2SO_4 bottle, otherwise the pressure build-up allows the scrubber liquid to force back into the lines as the O_2 is used up. This charge should be introduced over 30 seconds. The stopcock F_4 must remain in the closed Y position.

(2.8) The optimum precombustion time for rocks and soils is about 1½ minutes, but this depends upon the type of sample material. Too long a period results in reduced accuracy due to the increasing prominance of leaks and diffusion. Too short a period precombustion time also reduced the accuracy involved as not all the carbon may have been converted to CO_2. It is advisable to conduct a series of trial runs with the one sample for different precombustion times, in order to determine

the optimum precombustion time for that sample type. Once this period of time has been established, it should be consistently adhered to.

(2.9) During this precombustion time, both the production of CO_2 and the heating of the gases in the combustion tube results in an expansion of the gases and an increase in pressure. This will force the concentrated H_2SO_4 in the scrubber (no. 3) back through the oxygen purifying train, unless the increased pressure is balanced by slightly turning on the oxygen supply. This matching of pressures must be maintained throughout the precombustion time.

(1.10) After the combustion, OPEN the LOWER STOPCOCK to the burette (⊥ position). The oxygen flow valve on the gas bottle 'A' is then opened and adjusted to a flow rate sufficient to displace the liquid from the burette in about 1½ minutes. As the gas reaches the bottom of the burette bulb 'J' the oxygen volume should be reduced to prevent over-shooting of the zero mark.

(2.11) The levelling bottle is used to keep the liquid in the bottle and the burette approximately equal during the filling of the burette.

(2.12) As the liquid-gas interface approaches the zero mark, the lower stopcock must be closed quickly so that the gas flow now passes to the atmosphere whilst the gas burette is sealed (⊢ position). The interface need not be exactly at zero, but must not be less than zero, or the combustion must be repeated.

(2.13) The liquids in the burette and the levelling bottle are levelled, the top stopcock is closed, and the first reading is taken.

(2.14) The oxygen supply is then turned off, the furnace stoppers removed and the boat pulled out of the tank with the plunger. Drop the boat into a steel dustpan containing an asbestos mat.

3. ABSORPTION OF THE CARBON DIOXIDE IN THE BURETTE.

(3.1) The upper stopcock 'H' is opened to connect the burette to the CO_2 absorber and the levelling bottle 'M' is raised. This allows the liquid to return to the burette forcing the gas through the absorber 'K'.

(3.2) The gas is returned to the burette by lowering the levelling bottle.

(3.3) The time taken to pass the gas through the absorber should be about 1 minute in each direction.

(3.4) The absorption procedure is repeated to ensure complete removal of the CO_2.

(3.5) After the gas is returned for the second time, the levelling bottle is used to ensure the levels in the KOH trap 'L' are equal. Consequently the complete absorption sequence takes 4 minutes.

(3.6) The upper stopcock is closed and the liquids in bottle and burette levelled to obtain the second reading.

(3.7) The temperature and atmospheric pressure are recorded.

(3.8) The upper stopcock is opened to connect the burette to the lower stopcock, which is in turn opened to the atmosphere. The levelling bottle is raised to allow the liquid to return to the burette, expelling the gas.

(3.9) The apparatus is now ready for the next determination.

4. RESULTS.

(4.1) The percentage carbon in each sample can now be calculated using the equation:-

% carbon = change in volume (%) x correction factor.

The correction factor allows for the temperature of the gas and the atmospheric pressure. A table of correction factors is provided with the instrument.

(4.2) The results are most efficiently tabulated in the following form:-

Sample Number	Sample Weight	Initial Reading	Final Reading	Change in Volume	Change in volume for (sample weight of 1g) (%)	Average change in volume for 1 sample %	Temp °C	Pressure Hg mm	Correction factor	%C

(4.3) Some useful conversions for pressure units are:-

(i) 760 mm Hg ≡ 1,013.3 millibars

(ii) 1 inch Hg ≡ 25.4 mm Hg

(iii) Atmospheric pressure decreases by 1 millibar for every 28 feet above sea level.

5. DETECTION OF LEAKS.

(5.1) Under the elevated pressure conditions within the system, leaks can occur in any of three main sections of the combustion equipment. These are:- (1) the oxygen purifying train from the ball valve to the final H_2SO_4 scrubber; (2) the combustion train from the oxygen H_2SO_4 scrubber to the Cr_2O_3/H_2SO_4 scrubber of the CO_2 train, and (3) the CO_2 purifying train from the Cr_2O_3/H_2SO_4 scrubber to the threeway stopcock.

(5.2) If a leak is present in section 1, the liquid in the H_2SO_4 scrubber will be forced back towards the oxygen supply, as will the liquid in the Cr_2O_3/H_2SO_4 scrubber. Provided the leak is not in the combustion tube plug and a constant pressure is applied to the scrubber, minor leaks in this section are not critical.

(5.3) The following procedure will check for any leaks in the combustion tube plug. Remove the plug, cover the hole in it and apply moderate gas pressure. A leak within the plug is indicated by a steady stream of bubbles passing through the H_2SO_4 scrubber.

(5.4) If a leak is present in section 2, gas will consistently bubble through the H_2SO_4 scrubber and liquid will be sucked back from the Cr_2O_3/H_2SO_4 scrubber. This could be indicative of a nearby leak, or more serious, a cracked combustion tube.

(5.6) Leaks in either section 2 or 3 will effect the final results and hence must be repaired before proceeding with the analyses.

(5.7) It should be noted that while the equipment is operating, slight pressure differences will exist, giving rise to some minor displacement of gas and/or liquid through either scrubber.

A P P E N D I X C

SPECIMEN CATALOGUE.

The following list of specimens has been filed in the Geology Department, University of Tasmania catalogue.

Table C.1 lists the vegetation samples and Table C.2 lists the litter samples. These samples have been dried and crushed to a powder.

Table C.3 lists the air-dried, powdered soil samples while Table C.4 lists the rock samples collected. These are stored as rock powder and hand specimens. Each sample is located on the West Hercules grid by two co-ordinates (Figure 2.1).

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45152	53	Coprosma nitida	800N	00W
45153	55	" "	800N	400W
45154	14	" "	800N	700W
45155	24	Olearia phlogopappa (Dolly wood)	800N	700W
45156	32	" " (Murchison Mine.)	800N	
45157	82	Gahnia grandis (Cutting grass)	400N	700W
45158	85	" "	400N	1125W
45159	40	" "	400N	1300W
45160	84	" "	800N	00W
45161	83	" "	800N	200W
45162	81	" "	800N	400W
45163	7	" "	800N	700W
45164	57	" "	800N	800W
45165	86	" " (Murchison Mine)	800N	
45166	112	Anodopetalum biglandulosum (Horizontal) (twigs)	400N	200W
45167	113	"	400N	200W
45168	48	"	400N	480W
45169	47	"	400N	600W
45170	67	"	400N	700W
45171	104	"	400N	900W
45172	30	"	400N	1125W
45173	43	"	400N	1300W
45174	50	"	800N	00W
45175	20	"	800N	200W
45176	65	"	800N	800W
45177	2	"	800N	1000W

TABLE C.1. Vegetation Samples

Catalogue NO.	Field No.	Description	Northing	Easting
45178	106	Nothofagus cunninghamii (Myrtle) (twigs)	400N	200W
45179	107	" (leaves)	400N	200W
45180	116	" (twigs)	400N	480W
45181	117	" (leaves)	400N	480W
45182	60	"	400N	600W
45183	73	"	400N	700W
45184	114	" (twigs)	400N	900W
45185	115	" (leaves)	400N	900W
45186	36	"	400N	1125W
45187	49	"	400N	1300W
45188	18	"	800N	200W
45189	25	"	800N	400W
45190	19	"	800N	700W
45191	16	"	800N	800W
45192	21	"	800N	1000W
45193	94	Agastachys odorata	400N	200W
45194	66	" "	400N	480W
45195	102	" "	400N	400W
45196	75	" "	800N	200W
45197	12	" "	800N	400W
45198	37	Microsorium diversifilium (fern)	400N	700W
45199	96	"	400N	900W
45200	38	"	400N	1125W
45201	45	"	400N	1300W
45202	4	"	800N	700W
45203	79	"	800N	700W
45204	6	"	800N	800W
45205	3	"	800N	1000W
45206	101	" (murchison Mine)	800N	

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45207	78	Olearia alpina	400N	480W
45208	97	" "	400N	600W
45209	98	Persoonia gunii	400N	200W
45210	54	" "	800N	00W
45211	59	" "	800N	200W
45212	63	" "	800N	400W
45213	110	Eucryphia lucida (twigs)	400N	480W
45214	111	" "(leaves)	400N	480W
45215	62	" "	400N	600W
45216	100	" "	400N	700W
45217	44	" "	400N	900W
45218	105	" "	400N	1125W
45219	41	" "	400N	1300W
45220	58	" "	800N	700W
45221	71	" "	800N	700W
45222	61	" "	800N	1000W
45223	56	" "	800N	1000W
45224	26	Acacia melanoxylon (Blackwood)	800N	400W
45225	103	" (Murchison mine)	800N	
45226	72	Cenarrhenes nitida (Native Plum)	400N	200W
45227	95	" "	400N	480W
45228	89	" "	400N	600W
45229	93	" "	400N	700W
45230	39	" "	400N	900W
45231	46	" "	400N	1300W
45232	10	" "	800N	00W
45233	74	" "	800N	200W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45234	90	Leptospermum nitidum (Tea tree)	400N	200W
45235	70	"	400N	480W
45236	42	"	400N	600W
45237	68	"	800N	00W
45238	13	"	800N	200W
45239	11	"	800N	400W
45240	15	"	800N	700W
45241	27	" (Murchison Mine)	800N	
45242	92	Acacia mucronata	Murchison Mine	
45243	99	" "	"	"
45244	76	Atherosperma moschatum (Sassafras.)	400N	480W
45245	91	" "	400N	700W
45246	108	" "(twigs)	400N	900W
45247	109	" "(leaves)	400N	900W
45248	34	" "	400N	1125W
45249	35	" "	400N	1300W
45250	23	" "	800N	700W
45251	64	" "	800N	800W
45252	1	" "	800N	1000W
45253	88	Cyathodes juniperina	400N	480W
45254	87	" "	400N	600W
45255	52	" "	800N	00W
45256	51	" "	800N	400W
45257	28	Phebalium squameum (Satin wood)	Close to Murchison Mine	
45258	33	Momotoca elliptica	"	"

Table C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45259	77	Eucalyptus obliqua	Close of Murchison Mine.	
45260	22	Contamination Check		
45261	29	Pteridium esculentum	"	"
45262	512	Leptospermum nitidum (Contamination Check)	400N	300W
45263	9	Nothofagus cunninghamii (Contamination Check)		
45264	8	Contamination Check		
45265	69	Contamination Check		
45266	80	Contamination Check.		
45267	500	Leptospermum (Wood) nitidum (Tea Tree)	400N	500E
45268	501	" "	400N	400E
45269	502	" "	400N	00W
45270	503	" "	400N	300W
45271	504	" "	400N	400W
45272	505	" "	400N	500W
45273	506	Leptospermum (Bark) nitidum (Tea Tree)	400N	Ridge Top
45274	507	" "	400N	500E
45275	508	" "	400N	400E
45276	509	" "	400N	200E
45277	510	" "	400N	00W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45278	511	Leptospermum nitidum (Bark) (Tea Tree) (cont'd)	400N	200W
45279	513	" "	400N	400W
45280	514	" "	400N	500W
45281	515	" "	400N	600W
45282	516	" "	400N	600W
45283	517	Leptospermum nitidum (twigs) (Tea tree)	400N	Ridge Top
45284	518	" "	400N	500E
45285	519	" "	400N	400E
45286	520	" "	400N	200E
45287	521	" "	400N	00W
45288	522	" "	400N	200W
45289	523	" "	400N	300W
45290	524	" "	400N	400W
45291	525	" "	400N	400W
45292	526	" "	400N	500W
45293	527	" " (Twigs & leaves)	400N	600W
45294	528	Leptospermum nitidum (Leaves) (Tea Tree)	400N	Ridge Top
45295	529	" "	400N	500E
45296	530	" "	400N	400E
45297	531	" "	400N	200E
45298	532	" "	400N	00W
45299	533	" "	400N	200W
45300	534	" "	400N	300W
45301	535	" "	400N	400W
45302	536	" "	400N	400W
45303	537	" "	400N	500W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45304	538	Check with 512 (Bark)	400N	300W
45305	539	Check with 530 (Leaves)	400N	400E
45306	540	Anodopetalum biglandulosum Wood (saw) (Horizontal)	400N	700W
45307	541	" (Chisel)	400N	800W
45308	542	" "	400N	900W
45309	543	" Bark	400N	700W
45310	544	" "	400N	800W
45311	545	" "	400N	900W
45312	546	" "	400N	1000W
45313	547	" "	400N	1100W
45314	548	" "	400N	1200W
45315	549	" "	400N	1300W
45316	550	Anodopetalum biglandulosum (Horizontal) Twigs	400N	700W
45317	551	"	400N	800W
45318	552	" "	400N	900W
45319	553	" "	400N	1000W
45320	554	" "	400N	1100W
45321	555	" "	400N	1200W
45322	556	" "	400N	1300W
45323	557	Anodopetalum biglandulosum (Horizontal) Leaves	400N	700W
45324	558	" "	400N	800W
45325	559	" "	400N	900W
45326	560	" "	400N	1000W
45327	561	" "	400N	1100W
45328	562	" "	400N	1200W
45329	563	" "	400N	1300W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45330	564	Anodopetalum biglandulosum Bark Check (Horizontal) with 543	400N	700W
45331	565	Nothofagus cunninghamii (Myrtle) Wood	400N	Ridge Top
45332	566	" "	400N	00W
45333	567	" "	400N	400W
45334	568	" "	400N	500W
45335	569	" "	400N	600W
45336	570	" "	400N	700W
45337	571	" "	400N	800W
45338	572	" "	400N	900W
45339	573	" "	400N	1100W
45340	574	" "	400N	1200W
45341	575	Nothofagus cunninghamii (Myrtle) Bark	400N	Ridge Top
45342	576	" "	400N	00W
45343	577	" "	400N	300W
45344	578	" "	400N	400W
45345	579	" "	400N	500W
45346	580	" "	400N	600W
45347	581	" "	400N	700W
45348	582	" "	400N	800W
45349	583	" "	400N	900W
45350	584	" "	400N	1000W
45351	585	" "	400N	1100W
45352	586	" "	400N	1200W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45353	587	Nothofagus cunninghamii (Myrtle) Twigs	400N Ridge Top	
45354	588	" "	400N	00W
45355	589	" "	400N	300W
45356	590	" "	400N	400W
45357	591	" "	400N	500W
45358	592	" "	400N	600W
45359	593	" "	400N	700W
45360	594	" "	400N	800W
45361	595	" "	400N	900W
45362	596	" "	400N	1000W
45363	597	" "	400N	1100W
45364	598	" "	400N	1200W
45365	599	" " 2nd-4th yr.twigs	400N	1300W
45366	600	" " 1st yr. twigs	400N	1300W
45367	601	Nothofagus cunninghamii (Myrtle) Leaves	400N Ridge Top	
45368	602	" "	400N	00W
45369	603	" "	400N	300W
45370	604	" "	400N	400W
45371	605	" "	400N	500W
45372	606	" "	400N	600W
45373	607	" "	400N	700W
45374	608	" "	400N	800W
45375	609	" "	400N	900W
45376	610	" "	400N	1000W
45377	611	" "	400N	1100W
45378	612	" "	400N	1200W
45379	613	" "	400N	1300W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45380	614	*Nothofagus cunninghamii* (Myrtle) Bark Check with 582	400N	800W
45381	615	*Leptospermum nitidum* (Tea tree) Bark	400N	480W
45382	616	" Wood	400N	480W
45383	617	" 4th-7th yr. twigs	400N	480W
45384	618	" 1st-2nd yr. twigs	400N	480W
45385	619	" Leaves	400N	480W
45386	620	" Bark	400N	480W
45387	621	" 4th-7th yr. twigs	400N	480W
45388	622	" 1st-2nd yr. twigs	400N	480W
45389	623	" Leaves	400N	480W
45390	624	*Nothofagus cunninghamii* (Myrtle) Bark	400N	480W
45391	625	" Wood (saw cut)	400N	480W
45392	626	" 3rd-7th yr. twigs	400N	480W
45393	627	" 1st-2nd yr. twigs	400N	480W
45394	628	" Leaves.	400N	480W
45395	629	" Bark.	400N	480W
45396	630	" Wood.	400N	480W
45397	631	" 34d-4th yr. twigs.	400N	480W
45398	632	" 1st-2nd yr. twigs.	400N	480W
45399	633	" Leaves.	400N	480W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45400	634	Nothofagus cunninghamii (Myrtle) Bark	400N	700W
45401	635	" 3rd-4th yr. twigs	400N	700W
45402	636	" 1st-2nd yr. twigs	400N	700W
45403	637	" Leaves.	400N	700W
45404	638	" Bark.	400N	700W
45405	639	" (Saw cut) Wood.	400N	700W
45406	640	" 3rd-4th yr. twigs	400N	700W
45407	641	" 1st-2nd yr. twigs.	400N	700W
45408	642	" Leaves.	400N	700W
45409	643	Anodopetalum biglandulosum (Horizontal) Bark	400N	700W
45410	644	" Wood (Saw cut)	400N	700W
45411	645	" 3rd-4th yr. twigs.	400N	700W
45412	646	" 1st-2nd yr. twigs.	400N	700W
45413	647	" Leaves.	400N	700W
45414	648	" Bark.	400N	700W
45415	649	" Wood (Saw cut)	400N	700W
45416	650	" 3rd-4th yr. twigs.	400N	700W
45417	651	" 1st-2nd yr. twigs	400N	700W
45418	652	" Leaves.	400N	700W
45419	653	Leptospermum nitidum (Tea Tree) Bark. Check with 615	400N	480W
45420	654	Check with 634	400N	700W
45421	660	Nothofagus cunninghamii (Leaf samples)	800S	100E
45422	661	"	800S	50W

TABLE C.1. Vegetation Samples

Catalogue No.	Field No.	Description	Northing	Easting
45423	662	*Nothofagus cunninghamii* (cont'd) (Leaf samples)	800S	225W
45424	663	"	800S	250W
45425	664	"	800S	300W
45426	665	"	800S	350W
45427	666	"	800S	400W
45428	667	"	800S	500W
45429	668	"	800S	600W
45430	669	"	800S	680W
45431	670	"	800S	700W
45432	671	"	800S	825W
45433	672	"	800S	850W
45434	673	"	800S	900W
45435	674	"	800S	1000W
45436	675	"	800S	1050W
45437	676	"	800S	1100W
45438	677	"	800S	1200W
45439	678	"	800S	1250W
45440	679	"	800S	1300W

TABLE C.2 Litter Samples

Catalogue No.	Field No.	Northing	Easting
45441	332	2400S	500E
45442	333	2400S	180E
45443	331	2410S	25W
45444	334	2400S	200W
45445	330	2425S	250W
45446	335	2400S	350W
45447	336	2400S	520W
45448	337	800S	200E
45449	338	800S	00W
45450	339	800S	300W
45451	341	800S	400W
45452	340	300N	400E
45453	209	400N	200E
45454	342	400N	480W
45455	343	400N	600W
45456	344	400N	700W
45457	345	400N	900W
45458	346	400N	1125W
45459	347	400N	1300W
45460	348	800N	00W
45461	349	800N	400W
45462	350	800N	700W
45463	351	800N	800W
45464	352	800N	1000W

TABLE C.2. Litter Samples

Catalogue No.	Field No.	Northing	Easting
45465	353	1600N	15W
45466	354	1600N	200W
45467	355	1600N	600W
45468	350	1600N	790W
45469	357	Murchison 100 ft. from O/Cut.	
45470	358	"	

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45471	120	0-5	2425S	250W
45472	121	5-10	2425S	250W
45473	122	10-15	2425S	250W
45474	123	0-10	2410S	25W
45475	124	10-20	2410S	25W
45476	125	20-30	2410S	25W
45477	126	30-40	2410S	25W
45478	127	40-50	2410S	25W
45479	128	0-10	2400S	500E
45480	129	10-20	2400S	500E
45481	130	0-5	2400S	180E
45482	131	5-10	2400S	180E
45483	132	10-20	2400S	180E
45484	133	20-30	2400S	180E
45485	134	0-10	2400S	200W
45486	135	10-20	2400S	200W
45487	136	20-30	2400S	200W
45488	137	30-40	2400S	200W
45489	138	40-50	2400S	200W
45490	139	0-10	2400S	350W
45491	140	10-15	2400S	350W
45492	141	15-20	2400S	350W
45493	142	20-30	2400S	350W
45494	143	30-40	2400S	350W
45495	144	40-50	2400S	350W
45496	145	50-60	2400S	350W
45497	146	50-60	2400S	350W
45498	147	0-10	2400S	520W
45499	148	10-20	2400S	520W
45500	149	20-30	2400S	520W

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45501	150	30-40	2400S	520W
45502	151	40-50	2400S	520W
45503	152	40-50	2400S	520W
45504	153	50-60	2400S	520W
45505	154	60-70	2400S	520W
45506	155	70-80	2400S	520W
45507	156	80-90	2400S	520W
45508	157	90-100	2400S	520W
45509	158	0-10	800S	200E
45510	159	10-20	800S	200E
45511 Grinder	160	10-20	800S	200E
45512	161	20-30	800S	200E
45513	162	30-40	800S	200E
45514	163	0-10	800S	00W
45515	164	10-20	800S	00W
45516 Unmixed	165	20-30	800S	00W
45517 Mixed	166	20-30	800S	00W
45518 Unmixed	167	30-40	800S	00W
45519 Mixed	168	30-40	800S	00W
45520 Mixed	169	40-50	800S	00W
45521 Unmixed	170	40-50	800S	00W
45522 Unmixed	171	50-60	800S	00W
45523 Mixed	172	50-60	800S	00W
45524 Unmixed	173	60-70	800S	00W
45525 Mixed	174	60-70	800S	00W
45526 Unmixed	175	70-80	800S	00W
45527 Mixed	176	70-80	800S	00W

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45528	177	0-10	800S	300W
45529	178	10-20	800S	300W
45530	179	20-30	800S	300W
45531	180	30-40	800S	300W
45532	181	40-50	800S	300W
45533	182	50-60	800S	300W
45534	183	60-70	800S	300W
45535	184	70-80	800S	300W
45536	185	80-90	800S	300W
45537	186	90-100	800S	300W
45538	187	100-110	800S	300W
45539	188	110-120	800S	300W
45540	189	0-10	800S	400W
45541	190	10-20	800S	400W
45542	191	20-30	800S	400W
45543	192	30-40	800S	400W
45544	193	40-50	800S	400W
45545	194	50-60	800S	400W
45546	195	60-70	800S	400W
45547	196	70-80	800S	400W
45548	197	80-90	800S	400W
45549	198	90-100	800S	400W
45550	199	100-110	800S	400W
45551	200	110-120	800S	400W
45552	201	120-130	800S	400W
45553	202	120-130	800S	400W
45554	203	0-10	300N	500E
45555	204	10-20	300N	500E
45556	205	10-20	300N	500E

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45557	206	20-30	300N	500E
45558	207	30-40	300N	500E
45559	208	40-50	300N	500E
45560	209	litter	400N	200E
45561	210	0-10	400N	200E
45562	211	10-20	400N	200E
45563	212	0-10	400N	225W
45564	213	10-20	400N	225W
45565	214	10-20	400N	225W
45566	215	20-30	400N	225W
45567	216	30-40	400N	225W
45568	217	0-5	400N	480W
45569	218	5-10	400N	480W
45570	219	10-20	400N	480W
45571	220	20-30	400N	480W
45572	221	30-40	400N	480W
45573	222	0-10	400N	600W
45574	223	10-20	400N	600W
45575	224	20-30	400N	600W
45576	225	0-10	400N	700W
45577	226	10-20	400N	700W
45578	227	20-30	400N	700W
45579	228	30-40	400N	700W
45580	229	40-50	400N	700W
45581	230	50-60	400N	700W
45582	231	60-70	400N	700W
45583	232	70-80	400N	700W
45584	233	70-80	400N	700W
45585	234	80-90	400N	700W

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45586	235	1-2.5	400N	900W
45587	236	2.5-10	400N	900W
45588	237	10-20	400N	900W
45589	238	20-25	400N	900W
45590	239	25-30	400N	900W
45591	240	30-40	400N	900W
45592	241	40-50	400N	900W
45593	242	50-60	400N	900W
45594	243	60-65	400N	900W
45595	244	65-70	400N	900W
45596	245	0-10	400N	1125W
45597	246	10-20	400N	1125W
45598	247	20-30	400N	1125W
45599	248	30-40	400N	1125W
45600	249	30-40	400N	1125W
45601	250	40-50	400N	1125W
45602	251	0-10	400N	1300W
45603	252	10-15	400N	1300W
45604	253	15-20	400N	1300W
45605	254	20-25	400N	1300W
45606	255	25-30	400N	1300W
45607	256	30-35	400N	1300W
45608	257	35-40	400N	1300W
45609	258	40-50	400N	1300W
45610	259	0-10	800N	00W
45611	260	10-20	800N	00W
45612	261	20-30	800N	00W
45613	262	30-40	800N	00W
45614	263	litter	800N	200W
45615	264	0-10	800N	200W
45616	265	10-20	800N	200W

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45617	266	20-25	800N	200W
45618	267	0-10	800N	400W
45619	268	10-20	800N	400W
45620	269	0-5	800N	700W
45621	270	5-10	800N	700W
45622	271	10-20	800N	700W
45623 Grinder	272	20-30	800N	700W
45624 M & P	273	20-30	800N	700W
45625	274	30-40	800N	700W
45626	275	40-50	800N	700W
45627	276	40-50	800N	700W
45628	277	50-60	800N	700W
45629 M & P	278	50-60	800N	700W
45630	279	60-70	800N	700W
45631	280	70-80	800N	700W
45632	281	80-90	800N	700W
45633	282	0-10	800N	800W
45634	283	10-20	800N	800W
45635	284	20-30	800N	800W
45636	285	30-40	800N	800W
45637	286	40-50	800N	800W
45638	287	50-60	800N	800W
45639	288	60-70	800N	800W
45640	289	0-10	800N	1000W
45641	290	10-20	800N	1000W
45642	291	20-30	800N	1000W
45643	292	30-40	800N	1000W
45644	293	40-50	800N	1000W
45645	294	50-60	800N	1000W

TABLE C.3. Soil Samples

Catalogue No.	Field No.	Depth (cm)	Northing	Easting
45646	295		1600N	15W
45647	296	0-10	1600N	15W
45648	297	10-20	1600N	15W
45649	298	20-30	1600N	15W
45650	299	0-5	1600N	200W
45651	300	5-10	1600N	200W
45652	301	10-20	1600N	200W
45653	302	20-30	1600N	200W
45654	303	30-40	1600N	200W
45655	304	40-50	1600N	200W
45656	305	50-60	1600N	200W
45657	306	60-70	1600N	200W
45658	307	70-80	1600N	200W
45659	308	80-90	1600N	200W
45660	309	90-100	1600N	200W
45661	310	100-110	1600N	200W
45662	311	110-120	1600N	200W
45663	312	0-10	1600N	600W
45664	313	10-20	1600N	600W
45665	314	20-30	1600N	600W
45666	315	30-40	1600N	600W
45667	316	40-50	1600N	600W
45668	317	0-10	1600N	790W
45669	318	10-20	1600N	790W
45670	319	20-30	1600N	790W
45671	320	0-10	100 ft. from Murchison Mine.	
45672	321	10-20	"	
45673	322	20-30	"	
45674	323	30-40	"	
45675	324	0-10	On Murchison Mine.	

TABLE C.4. Rocks.

There are two main types of lithologies encountered in the project area:-

(a) White highly siliceous fine grained schistose crystal tuff, and

(b) Green medium to coarse gained sericite crystal tuff often with albitization.

For simplicity, these are listed under "Description" as (a) or (b).

Catalogue No.	Field No.		Description	Northing	Easting
45676	361		a	2400S	500E
45677	362		b	2400S	180E
45678	363		shale	2400S	200W
45679	360		shale	2425S	250W
45680	364		b	2400S	350W
45681	365		b	2400S	520W
45682	366		b	800S	200E
45683	367		b	800S	00W
45684	368		b	800S	300W
45685	369		a	800S	400W
45686	A370	Bull-dozer road	a	200N	200E
45687	B371		a	200N	200E
45688	C372		a	200N	200E
45689	373		a	300N	500E
45690	374		a	400N	200E
45691	375		a	400N	225W
45692	376		a	400N	480W
45693	377		b	400N	600W
45694	378		b	400N	700W
45695	379		b	400N	1125W
45696	380			400N	1300W

TABLE C.4. Rocks.

Catalogue No.	Field No.	Description	Northing	Easting
45697	381	a	800N	00W
45698	382	a	800N	150W
45699	383	a	800N	200W
45700	384	a	800N	300W
45701	385	a	800N	400W
45702	386	b	800N	700W
45703	387	b	800N	800W
45704	388	b	800N	1000W
45705	389	a	1600N	15W
45706	390	b	1600N	200W
45707	391	b	1600N	600W
45708	392	b	1600N	600W
45709	393	b	1600N	790W
45710	394	Murchison Mine		
45711	395 (Check 363)	shale	2400S	200W
45712	396 (Check 367)	b	800S	00W
45713	397 (Check 369)	a	800S	400W
45714	398 (Check 370)	Bulldozer road.	200N	200E
45715	399	a	800N	150W
45716	400	shale	2425S	250W
45717	401		400N	900W
45718	402	Mineralization	400N	200E
45719	403	Access Track - Mn deposits		
45720	404	Mineralized "augen"	400N	200E

APPENDIX D.1

(i) SPECIES BIOGEOCHEMICAL SURVEY

Plant Sampling done on: 19/1/75 for 800N ; 20/1/75 for 400N.

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Coprosma nitida							
Line 800N							
00W	53	10	55	0.16%	5	0.94%	360
400W	55	10	70	420	5	0.78%	700
700W	14	30	50	660	10	3.8%	460
Olearia phlogopappa (Dollywood)							
Line 800N							
700W	24	40	60	660	10	0.92%	840
Murchison Mine	32	10	25	190	5	0.23%	200
Gahnia grandis. (Cutting Grass)							
Line 400N							
700W	82	5	5	40	5	0.14%	70
1125W	85	10	2	40	15	920	95
1300W	40	10	10	50	10	0.20%	110
Line 800N							
00W	84	20	10	110	20	0.27%	180
200W	83	10	10	90	10	0.22%	80
400W	81	10	10	140	10	0.26%	95
700W	7	5	15	175	15	0.90%	340
800W	57	55	50	170	20	1.10%	300
Murchison Mine	86	5	5	50	5	0.16%	85
Anodopetalum biglandulosum (Horizontal)							
Line 400N							
200W	112(twigs)	20	50	60	10	0.84%	240
200W	113(leaves)	2	10	20	5	1.30%	60
480W	48	5	30	60	5	2.4%	160
600W	47	10	40	60	10	3.6%	260

APPENDIX D.1 (i)

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Anodopetalum biglandulosum (Horizontal) (Continued)							
Line 400N							
700W	67	5	40	90	10	1.85%	280
900W	104	2	5	40	5	0.88%	100
1125W	30	5	20	70	15	0.39%	180
1300W	43	5	20	80	10	0.70%	220
Line 800N							
00W	50	5	70	95	5	1.95%	210
200W	20	10	85	80	10	2.3%	400
800W	65	5	15	40	5	0.90%	170
1000W	2	5	30	70	10	0.64%	250
Nothofagus cunninghamii (Myrtle)							
Line 400N							
200W	106(twigs)	10	50	155	10	0.66%	380
200W	107(leaves)	2	10	80	5	0.62%	130
480W	116(twigs)	10	15	80	5	0.28%	230
480W	117(leaves)	<2	2	20	<5	0.13%	60
600W	60	30	35	240	5	2.2%	420
700W	73	25	30	260	10	1.10%	400
900W	114(twigs)	10	10	100	5	760	110
900W	115(leaves)	2	5	45	5	960	80
1125W	36	2	10	80	5	0.30%	175
1300W	49	10	30	240	30	0.48%	280
Line 800N							
200W	18	20	85	520	15	2.9%	760
400W	25	15	75	880	10	2.2%	680
700W	19	15	30	270	5	1.45%	330
800W	16	10	60	400	10	1.00%	740
1000W	21	40	70	540	20	1.25%	700

APPENDIX D.1 (i)

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Agastachys odorata							
Line 400N							
200W	94	<2	5	10	<5	440	35
480W	66	2	5	15	<5	720	35
400W	102	<2	2	15	<5	0.10%	60
Line 800N							
200W	75	5	10	60	5	0.22%	120
400W	12	<2	5	50	5	0.14%	135
Microsorium diversifilium (fern)							
Line 400N							
700W	37	10	160	65	5	0.21%	160
900W	96	2	10	30	5	0.16%	105
1125W	38	5	10	50	15	820	130
1300W	45	5	10	90	15	0.18%	170
Line 800N							
700W	4(fern)	2	40	90	5	0.68%	260
700W	79	5	5	300	5	0.50%	70
800W	6	2	30	70	5	980	190
1000W	3	2	20	60	10	0.10%	170
Murchison Mine	101	2	5	30	5	300	65
Olearia alpina							
Line 400N							
480W	78	145	35	0.12%	10	190%	500
600W	97	5	15	230	5	0.34%	140

APPENDIX D.1 (i)

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Persoonia gunnii							
Line 400N							
200W	98	<2	10	210	<5	0.16%	100
Line 800N							
00W	54	5	35	340	5	0.58%	180
200W	59	2	20	240	<5	0.38%	260
400W	63	5	10	280	5	0.50%	230
Eucryphia lucida							
Line 400N							
480W	110(twigs)	20	40	660	5	0.96%	180
480W	111(leaves)	5	10	300	5	1.40%	70
600W	62	10	20	240	10	1.30%	110
700W	100	5	15	320	5	1.20%	140
900W	44	5	20	400	15	0.66%	170
1125W	105	2	10	190	30	0.62%	70
1300W	41	5	25	580	70	0.78%	170
Line 800N							
700W	58	5	15	360	5	1.35%	170
700W	71	5	20	430	10	1.65%	220
1000W	61	20	40	0.14%	15	1.50%	280
1000W	56	10	25	800	10	1.15%	240
Acacia melanoxylon (Blackwood)							
Line 800N							
400W	26	2	30	140	10	0.66%	520
Murchison Mine	103	<2	5	75	5	0.30%	120

APPENDIX D.1 (i)

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Cenarrhenes nitida (Native Plum)							
Line 400N							
200W	72	5	30	140	10	0.12%	230
480W	95	<2	5	20	<5	520	40
600W	89	2	2	30	5	400	35
700W	93	2	10	20	<5	0.16%	45
900W	39	5	20	40	5	0.56%	50
1300W	46	5	20	50	10	0.34%	135
Line 800N							
00W	10	5	20	30	5	0.56%	110
200W	74	<2	5	35	5	0.13%	80
Leptospermum nitidum (Tea Tree)							
Line 400N 200W	90	2	10	70	5	0.30%	140
480W	70	10	30	340	10	1.40%	400
600W	42	10	35	360	15	2.2%	400
Line 800N							
00W	68	5	40	190	10	1.90%	280
200W	13	35	105	460	15	1.05%	720
400W	11	5	55	195	10	0.84%	400
700W	15	30	55	500	10	2.2%	460
Murchison Mine	27	25	80	195	20	0.20%	660
Acacia mucronata							
Murchison Mine	92	<2	5	25	5	340	60
"	99	<2	5	40	<5	400	65

APPENDIX D.1 (i)

Easting:	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
Atherosperma moschatum (Sassafras)							
Line 400N							
480W	76	30	30	155	10	3.0%	400
700W	91	2	10	25	5	0.74%	85
900W	108(twigs)	10	15	70	5	0.36%	150
900W	109(leaves)	2	10	30	5	0.70%	120
1125W	34	2	20	85	25	0.30%	330
1300W	35	2	20	65	20	0.72%	200
Line 800N							
700W	23	15	55	230	15	2.6%	700
800W	64	5	10	35	5	0.66%	110
1000W	1	5	30	105	10	1.50%	270
Cyathodes juniperina							
Line 400N							
480W	88	5	2	30	5	1.15%	75
600W	87	5	5	30	5	0.96%	90
Line 800N							
00W	52	35	45	145	10	2.7%	220
400W	51	10	70	110	10	1.55%	460

APPENDIX D.1 (i)

Close to Murchison Mine

Sample No.	Species:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe ppm
28	Phebalium squameum (Satin wood)	10	65	140	15	460	360
33	Momotoca elliptica	10	20	95	10	0.23%	190
77	Eucalyptus obliqua	2	10	55	10	0.92%	80
27	Leptospermum nitidum	25	80	195	20	0.20%	660
29	Pteridium esculentum	5	30	160	5	0.13%	120
32	Olearia phlogopappa (Dollywood)	10	25	190	5	0.23%	200
86	Gahnia grandis (Cutting grass)	5	5	50	5	0.16%	85
92	Acacia mucronata	<2	5	25	5	340	60
101	Microsorium diversifilium (fern)	2	5	30	5	300	65
103	Acacia melanoxylon (Blackwood)	<2	5	75	5	0.30%	120

DETAILED PILOT AND PLANT ORGAN SURVEY : ALL PLANT SAMPLES TAKEN ALONG LINE 400N

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
500E	500	Leptospermum nitidum (Tea Tree)	Wood	340	140	0.31%	65	5.6	0.12%	45	470
400E	501			0.11%	750	0.64%	175	4.8	0.23	100	750
00W	502			300	300	0.24%	110	3.1	0.13	35	0.14%
300W	503			550	880	0.26%	100	4.6	0.16	50	0.15%
400W	504			400	370	0.13%	115	3.4	0.40	40	0.15%
500W	505			320	380	0.19%	125	12.3	0.24	25	0.17%
Ridge Top	506	Leptospermum nitidum (Tea Tree)	Bark	0.11%	0.22%	0.42%	65	2.2	1.30	35	0.10%
500E	507			560	0.11%	0.25%	45	3.8	1.25	25	620
400E	508			920	0.14%	0.18%	40	1.60	1.35	25	400
200E	509			920	0.11%	940	40	3.5	1.30	25	260
00W	510			720	0.13%	0.22%	55	1.20	1.30	30	300
200W	511			680	840	0.26%	40	1.05	0.84	15	410
300W	512			740	560	0.15%	110	1.30	1.05	20	440
400W	513			520	300	0.17%	60	2.4	0.42	40	480
500W	514			195	175	900	75	1.65	0.50	25	310

(Sampling conducted during week ending 7/6/1975).

APPENDIX D.1 (ii)

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
600W	515)	Leptospermum nitidum	Bark	(115	130	660	20	1.50	0.15	40	300)
	)			(							)
600W	516)	(Tea Tree)	(cont'd)	(190	270	0.22%	100	9.9	1.00	30	250)
Ridge Top	517	Leptospermum nitidum (Tea Tree)	Twigs	230	0.10%	0.12%	40	3.5	0.24	15	250
500E	518			270	380	0.16%	50	3.9	0.20	30	300
400E	519			230	380	0.17%	35	3.1	0.14	30	300
200E	520			370	320	660	40	2.2	0.16	25	490
00W	521			260	460	0.15%	65	1.95	0.30	40	310
200W	522			110	150	680	20	1.65	0.15	10	250
300W	523			195	210	0.13%	40	2.6	0.20	20	200
400W	524)			(270	210	880	35	4.0	0.24	20	200)
	)			(							)
400W	525)			(760	230	960	50	1.75	0.37	25	150)
500W	526			420	155	0.11%	55	4.4	0.32	15	165
600W	527		Twigs and leaves	160	185	0.14%	30	6.6	0.16	30	250

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
Ridge Top	528	Leptospermum nitidum (Tea Tree)	Leaves	80	420	700	25	7.3	0.18	10	300
500E	529			55	145	720	25	6.6	0.12	15	200
400E	530			35	60	470	15	3.1	420	10	100
200E	531			200	95	350	20	4.4	620	15	200
00W	532			60	170	720	20	3.7	0.12%	20	300
200W	533			80	105	700	20	4.4	0.13%	10	200
300W	534			95	115	0.13%	30	4.6	0.12%	15	200
400W	535)			(90	95	740	20	6.4	0.12%	10	200)
400W	536)			(140	140	960	50	8.8	0.14%	20	150)
500W	537			105	125	600	20	9.6	0.14%	15	190
300W	538	Check with 512 (bark)		450	350	920	60	0.92	0.62%	20	100
400E	539	Check with 530 (leaves)		85	165	960	25	7.3	920	25	200
700W	540	Anodopetalum biglandulosum (Horizontal)	Wood (saw)	0.16%	0.12%	0.15%	0.11%	5.7	1.35%	125	0.17%
800W	541		(Chisel)	820	0.15%	500	70	3.8	0.44%	25	0.14%
900W	542		(")	380	380	560	125	3.2	0.24%	30	940

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
700W	543	Anodopetalum biglandulosum (Horizontal)	Bark	280	540	560	35	4.2	0.21%	10	680
800W	544			320	760	280	20	4.0	0.21%	10	200
900W	545			280	620	820	45	2.1	0.15%	10	320
1000W	546			0.36%	0.44%	0.20%	350	15.0	1.60%	100	0.25%
1100W	547			190	170	110	20	0.80	0.14%	10	500
1200W	548			280	380	0.12%	55	1.15	0.16%	35	200
1300W	549			165	410	210	35	1.10	740	10	250
700W	550	Anodopetalum biglandulosum (Horizontal)	Twigs	880	350	780	195	2.7	0.24%	10	760
800W	551			480	340	520	40	3.3	0.16%	15	310
900W	552			680	0.15%	900	150	4.6	0.19%	20	720
1000W	553			175	180	520	80	1.65	0.11%	10	400
1100W	554			160	220	440	35	1.20	0.12%	10	560
1200W	555			380	820	920	120	1.30	0.15%	15	520
1300W	556			370	780	660	135	1.20	0.14%	10	0.12%

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
700W	557	Anodopetalum biglandulosum (Horizontal)	Leaves	100	115	270	35	5.7	0.15%	5	300
800W	558			130	110	470	25	4.3	880	10	350
900W	559			135	85	270	30	2.9	0.10%	5	150
1000W	560			100	105	340	60	3.6	920	5	300
1100W	561			90	150	290	45	2.9	0.12%	5	300
1200W	562			115	210	480	85	1.95	0.12%	10	350
1300W	563			20	65	290	50	2.6	800	10	400
700W	564	Anodopetalum biglandulosum (Horizontal)	Bark check with 543	290	450	580	30	4.3	0.20%	15	250
Ridge Top	565	Nothofagus cunninghamii (Myrtle)	Wood	520	290	0.15%	145	5.7	0.23%	40	0.15%
00W	566			500	195	0.22%	210	6.3	0.24%	40	0.19%
400W	567			280	100	0.11%	110	5.2	0.13%	35	0.15%
500W	568			210	100	0.15%	65	3.6	0.11%	20	0.13%
600W	569			280	140	0.16%	70	6.8	0.12%	25	840
700W	570			320	270	0.10%	165	3.2	0.23%	35	0.13%
800W	571			560	360	0.16%	50	2.4	0.50%	25	880

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
900W	572	Nothofagus cunninghamii (Myrtle)	Wood (cont'd)	680	460	0.14%	230	1.80	0.40%	35	0.20%
1100W	573			720	330	0.15%	380	3.7	0.52%	50	0.28%
1200W	574			380	195	0.10%	310	3.0	0.26%	40	0.23%
Ridge Top	575	Nothofagus cunninghamii (Myrtle)	Bark	290	780	0.28%	55	10.4	0.38%	45	500
00W	576			450	440	0.29%	65	6.3	0.38%	30	370
300W	577			520	270	0.36%	55	6.9	0.34%	25	360
400W	578			200	120	0.28%	35	6.6	0.14%	20	310
500W	579			540	270	0.29%	35	5.9	0.23%	25	580
600W	580			300	175	0.25%	40	5.1	0.19%	30	680
700W	581			680	440	0.28%	45	4.6	0.96%	25	470
800W	582			390	700	0.18%	190	4.0	0.44%	35	600
900W	583			440	490	0.13%	85	2.3	0.51%	15	660
1000W	584			310	200	0.14%	145	0.23	0.15%	15	620
1100W	585			250	125	0.10%	65	2.9	0.19%	20	450
1200W	586			170	150	760	105	2.0	0.10%	10	560

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
Ridge Top	587	Nothofagus cunninghamii (Myrtle)	Twigs	320	0.14%	0.22%	40	5.9	0.59%	20	560
00W	588			460	800	0.22%	95	6.8	0.48%	40	0.19%
300W	589			580	320	0.20%	75	6.5	0.32%	15	680
400W	590			400	360	0.31%	55	6.4	0.31%	30	490
500W	591			600	400	0.19	65	7.1	0.62%	20	370
600W	592			380	450	0.17	65	8.4	0.27%	35	0.27%
700W	593			580	220	0.21	125	5.2	0.29%	15	700
800W	594			430	260	0.13	40	2.8	0.18%	15	700
900W	595			700	420	0.29	125	2.9	0.31%	25	760
1000W	596			460	230	0.18	150	3.1	0.19%	20	680
1100W	597			330	160	0.17	135	3.1	0.14%	25	620
1200W	598			700	280	0.22	290	1.25	0.26%	15	0.13%
1300W	599		2nd, 4th year twigs	550	190	0.21	190	7.4	0.21%	25	0.11%
1300W	600		1st year twigs	520	230	0.18	105	5.2	0.22%	15	460

Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn %	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
Ridge Top	601	Nothofagus cunninghamii (Myrtle)	Leaves	145	440	0.16	30	1.85	0.12	15	300
00W	602			220	220	0.14	45	5.8	0.18	20	520
300W	603			310	195	0.18	40	8.6	0.25	5	420
400W	604			175	115	0.10	75	8.6	0.17	10	330
500W	605			270	190	0.14	45	5.4	0.16	10	550
600W	606			300	130	0.15	35	6.8	0.14	5	580
700W	607			700	490	0.19	50	5.1	0.54	20	380
800W	608			500	400	0.16	45	3.3	0.29	10	440
900W	609			480	290	0.16	105	2.4	0.21	10	330
1000W	610			430	270	0.14	105	2.5	0.18	15	500
1100W	611			460	165	0.10	65	3.6	0.15	10	270
1200W	612			550	310	0.15	150	4.4	0.26	15	250
1300W	613			410	220	0.16	145	7.5	0.26	10	400
800W	614	Nothofagus cunninghamii (Myrtle)	Bark (Check with 582)	330	620	0.17	35	3.5	0.22	40	500

Location:	Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn %	Ni ppm	Mn %	Fe %	Cd ppm	Ba ppm
Bottom	480W	615	Leptospermum nitidum (Tea Tree) 4 m.	Bark	540	260	0.15	70	0.58	0.44	20	320
"	480W	616		Wood	540	0.10%	0.16	420	0.88	0.58	135	0.13%
"	480W	617		4th-7th yr. twigs	540	180	0.16	100	1.45	0.21	15	230
"	480W	618		1st-2nd yr. twigs	480	260	0.14	45	1.55	0.40	15	200
"	480W	619		Leaves.	280	145	0.10	80	2.0	0.16	15	400
Top	480W	620		Bark	540	290	0.15%	55	0.70	0.53	15	380
"	480W	621		4th-7th yr. twigs	490	120	0.18	120	1.40	0.10	15	300
"	480W	622		1-2nd yr. twigs	490	350	0.12	50	1.05	0.32	10	240
"	480W	623		Leaves.	260	175	760	50	1.80	0.17	5	250
Bottom	480W	624	Nothofagus cunninghamii (Myrtle) 2·5m	Bark.	370	160	0.23	65	7.8	0.18	30	370
"	480W	625		Wood. (saw cut)	920	210	0.18	750	4.7	1.10	70	0.21%
"	480W	626		3rd-7th yr. twigs	600	165	0.19	145	7.3	0.24	25	960
"	480W	627		1st-2nd yr. twigs.	680	340	0.23	100	4.4	0.35	15	500
"	480W	628		Leaves.	520	160	0.16	75	4.3	0.21	5	410

Location:	Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe ppm	Cd ppm	Ba ppm
Top	480W	629	Nothofagus cunninghamii	Bark	330	210	0.16%	65	8.5	0.15%	25	0.16%
"	480W	630	(Myrtle)	Wood	440	65	0.10%	110	5.2	940	15	0.16%
"	480W	631	2.5m.	3rd-4th yr. twigs	540	180	0.12%	75	1.00	0.12%	10	0.11%
"	480W	632		1st-2nd yr. twigs	450	185	0.15%	60	5.0	0.18%	10	840
"	480W	633		Leaves.	310	110	0.13%	45	5.8	0.16%	10	310
Bottom	700W	634	Nothofagus cunninghamii	Bark	330	400	0.39%	45	3.9	0.19%	25	980
"	700W	635	(Myrtle)	3rd-4th yr. twigs	820	240	0.31%	170	4.9	0.27%	15	0.12%
"	700W	636	6 m.	1st-2nd yr. twigs	900	320	0.25%	125	4.0	0.29%	10	500
"	700W	637		Leaves.	440	250	0.16%	85	3.9	0.30%	5	430
Top	700W	638	Nothofagus cunninghamii	Bark	480	155	0.25%	95	3.6	0.34%	15	700
"	700W	639	(Myrtle)	(Saw cut) Wood	0.14%	210	3.3%	600	3.4	0.72%	210	0.21%
"	700W	640	6 m.	3rd-4th yr.twigs	520	195	0.14%	110	1.90	0.23%	15	0.21%
"	700W	641		1st-2nd yr. twigs	580	230	0.13%	85	1.20	0.24%	10	840
"	700W	642		Leaves.	420	200	0.12%	70	4.4	0.28%	20	840

Location:	Easting:	Sample No.	Species:	Organ:	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn %	Fe ppm	Cd ppm	Ba ppm
Bottom	700W	643	Anodopetalum biglandulosum (Horizontal) 6 m.	Bark	540	640	320	75	7.9	0.72%	5	370
"	700W	644		Wood (Saw cut)	0.28%	0.20%	860	0.19%	4.0	1.35%	250	0.20%
"	700W	645		3rd-4th yr. twigs	0.32%	0.11%	920	420	6.6	0.45%	15	760
"	700W	646		1st-2nd yr. twigs	540	450	390	120	4.5	0.53%	10	680
"	700W	647		Leaves.	170	270	200	40	7.7	0.25%	10	350
Top	700W	648	Anodopetalum biglandulosum (Horizontal) 6m.	Bark	600	310	410	105	5.5	0.29%	10	720
"	700W	649		Wood (Saw cut)	0.11%	460	780	500	4.1	0.78%	110	0.18%
"	700W	650		3rd-4th yr. twigs	0.10%	350	520	250	6.5	0.19%	15	0.10%
"	700W	651		2st-2nd yr. twigs	220	100	260	45	4.8	840	5	560
"	700W	652		Leaves.	130	35	155	30	4.6	240	5	300
Bottom	480W	653	Leptospermum nitidum (Tea Tree)	Bark	560	185	0.14%	50	0.54	0.26%	15	430
"	700W Check with 634	654		Check with 615	350	320	0.29%	45	1.75	0.12%	20	460

(iii) TRIAL BIOGEOCHEMICAL SURVEY

NOTHOFAGUS CUNNINGHAMII LEAF SAMPLES DOWN LINE 800S

Eastings	Sample No.	Fe %	Pb ppm	Ni ppm
100E	660	0.22	240	45
50W	661	0.16	120	35
225W	662	0.23	200	30
250W	663	0.20	120	30
300W	664	0.16	150	35
350W	665	0.16	145	40
400W	666	0.13	100	35
500W	667	0.11	120	85
600W	668	0.21	165	175
680W	669	0.32	135	320
700W	670	0.17	155	120
825W	671	0.14	120	260
850W	672	0.17	190	190
900W	673	0.13	100	380
1000W	674	0.32	115	160
1050W	675	0.15	120	85
1100W	676	0.20	170	90
1200W	677	0.14	105	105
1250W	678	0.31	105	230
1300W	679	0.15	115	238

(Sampling conducted on 13/1/1976)

APPENDIX D.2

LITTER SURVEY - (LITTER ANALYSES)

Northings	Eastings	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe %	Pb/Ni	Fe (Nix10)
2400S	500E	332	210	880	95	10	120	0.37	88	37
	180E	333	340	220	820	40	1.75%	1.00	5.5	25
2410S	25W	331	290	330	260	75	0.66%	5.1	4.4	68
2400S	200W	334	300	780	820	75	1.70%	2.3	10.4	30.7
2425S	250W	330	160	310	155	25	0.17%	0.46	12.4	18.4
2400S	350W	335	250	430	880	30	6.3%	0.70	14.3	23.3
	520W	336	550	400	0.13%	70	1.20%	1.55	5.7	22.1
800S	200E	337	530	0.12%	380	50	2.6%	1.70	24	34
	00W	338	410	440	320	50	1.25%	1.6	8.8	32
	300W	339	760	520	0.25%	70	1.75%	0.68	7.4	9.7
	400W	341	0.12%	0.30%	0.46%	50	2.4%	1.65	60	33
300N	400E	340	470	0.13%	0.12%	40	1.50%	2.7	32.5	67.5
400N	200E	209	15	520	60	15	0.18%	1.60%	34.7	106.7
	480W	342	410	880	660	50	1.15%	0.43	17.6	8.6
	600W	343	270	300	155	35	0.40%	0.32	8.6	9.1
	700W	344	190	0.24%	290	30	1.05%	6.8	80	226.7
	900W	345	215	0.14%	360	30	0.44%	1.30	46.7	43.3
	1125W	346	860	580	0.11%	160	0.98%	1.30	3.6	8.1
	1300W	347	280	200	380	80	0.70%	3.3	2.5	41.3
800N	00W	348	220	0.22%	580	25	0.96%	0.29	88	11.6
	400W	349	240	0.15%	0.11%	30	880	0.26	50	8.7
	700W	350	330	0.14%	0.11%	30	2.4%	2.9	46.7	96.7
	800W	351	260	0.36%	0.17%	35	2.7%	3.3	102.9	94.3
	1000W	352	310	300	400	50	1.20%	2.6	6	52

(Sampling conducted during week ending 9/2/1975)

APPENDIX D.2

Northings	Eastings	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Mn ppm	Fe %	Pb/Ni	Fe/(Nix10)
1600N	15W	353	200	350	700	40	0.31%	0.64	8.8	16
	200W	354	230	0.29%	560	30	0.92%	0.15	96.7	5
	600W	355	560	260	540	55	1.75%	0.54	8.7	9,8
	790W	350	350	270	440	40	0.66%	0.43	6.8	10.8
Murchison		357	340	140	140	40	0.48%	0.15		
100 ft. from O/Cut		358	160	720	65	10	105	0.28		

APPENDIX D.3

SOIL PROFILE ANALYSES

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm
2425S	250W	120)	0-5	10	170	35	10	0.40%	95
		121)	5-10	10	170	35	10	0.62%	50
		122	10-15	20	240	120	30	4.1%	120
2410S	25W	123	0-10	10	140	90	80	3.1%	560
		124	10-20	10	140	85	75	3.4%	270
		125	20-30	10	120	75	60	3.4%	290
		126	30-40	15	100	90	65	5.3%	520
		127	40-50	20	75	120	85	5.1%	580
2400S	500E	128	0-10	2	70	10	10	480	20
		129	10-20	5	75	5	5	720	20
2400S	180E	130)	0-5	10	70	35	5	0.54%	580
		131)	5-10	5	50	15	10	0.36%	85
		132	10-20	10	35	10	10	0.32%	45
		133	20-30	2	35	5	10	0.22%	20
2400S	200W	134	0-10	10	150	45	30	1.95%	155
		135	10-20	10	160	40	20	1.70%	110
		136	20-30	10	180	45	30	2.1%	135
		137	30-40	10	150	60	45	2.2%	125
		138	40-50	10	200	40	30	1.95%	75
2400S	350W	139	0-10	5	175	20	10	0.17%	350
		140)	10-15	5	130	15	10	0.16%	110
		141)	15-20	5	120	15	15	0.17%	105
		142	20-30	2	115	15	10	0.14%	80
		143	30-40	2	100	10	15	0.16%	45
		144	40-50	2	125	15	10	0.14%	75
		145)	50-60	2	70	15	10	0.12%	20
		146)		2	70	10	10	0.13%	20

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm
2400S	520W	147	0-10	5	145	25	15	0.62%	80
		148	10-20	5	120	25	15	0.63%	40
		149	20-30	2	120	20	10	0.58%	35
		150	30-40	2	120	25	10	1.05%	30
		151)	40-50	2	120	35	10	0.92%	25
		152)		2	120	35	10	0.92%	20
		153	50-60	2	115	25	15	0.56%	15
		154	60-70	2	120	25	10	0.44%	15
		155	70-80	2	115	20	10	0.42%	15
		156	80-90	<2	110	25	10	0.60%	20
		157	90-100	2	55	45	10	1.10%	50
800S	200E	158	0-10	15	660	50	10	0.84%	0.48%
		159)	10-20	15	0.10%	35	10	1.15%	0.38%
	Grinder	160)		15	0.11%	40	5	1.30%	0.48%
		161	20-30	15	880	65	10	1.40%	0.52%
		162	30-40	15	880	60	15	1.60%	0.54%
800S	00W	163	0-10	10	210	35	10	0.96%	0.12%
		164	10-20	10	260	55	5	1.80%	0.26%
	unmixed	165)	20-30	10	300	45	10	1.65%	0.24%
	mixed	166)		10	300	45	10	1.65%	0.24%
	unmixed	167)	30-40	15	380	15	10	1.80%	0.27%
	mixed	168)		10	340	40	5	2.0%	0.32%
	mixed	169)	40-50	15	440	65	10	2.0%	0.47%
	unmixed	170)		20	500	85	10	2.0%	0.54%
	unmixed	171)	50-60	15	340	75	5	1.95%	0.52%
	mixed	172)		15	360	80	5	2.0%	0.52%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm
800S	00W unmixed	173	60-70	15	320	75	10	1.85%	0.47%
	mixed	174		15	320	75	10	1.75%	0.46%
	unmixed	175	70-80	15	300	190	5	1.75%	0.50%
	mixed	176		15	320	70	5	1.80%	0.52%
800S	300W	177	0-10	15	130	60	15	0.30%	200
		178	10-20	55	480	185	10	1.35%	0.18%
		179	20-30	60	440	200	10	1.60%	0.18%
		180	30-40	100	540	400	10	1.05%	30
		181	40-50	140	580	660	10	0.92%	25
		182	50-60	100	440	800	15	0.92%	20
		183	60-70	100	440	800	10	0.56%	15
		184	70-80	95	400	800	10	0.44%	15
		185	80-90	75	340	660	15	0.42%	15
		186	90-100	45	300	460	15	0.60%	20
		187	100-110	55	400	540	10	1.10%	50
		188	110-120	65	400	500	10	0.84%	0.48%
800S	400W	189	0-10	250	800	460	<5	1.15%	0.38%
		190	10-20	340	800	700	5	1.30%	0.48%
		191	20-30	380	720	880	5	1.40%	0.52%
		192	30-40	400	0.10%	0.10%	10	1.60%	0.54%
		193	40-50	400	960	0.10%	10	0.96%	0.12%
		194	50-60	400	800	0.12%	10	1.80%	0.26%
		195	60-70	340	700	0.11%	10	1.65%	0.28%
		196	70-80	340	680	0.11%	10	1.65%	0.24%
		197	80-90	340	700	0.12%	10	1.80%	0.27%
		198	90-100	290	600	0.10%	10	2.0%	0.32%
		199	100-110	220	500	880	10	2.0%	0.47%
		200	110-120	240	500	940	5	2.0%	0.54%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm
800S	400W	201)	120-130	150	360	680	10	1.95%	0.52%
		202)		150	380	700	10	2.0%	0.52%
300N	500E	203	0-10	80	0.52%	250	5	1.85%	0.47%
		204)	10-20	70	1.20%	80	<5	1.75%	0.46%
		205)		70	1.20%	85	5	1.75%	0.50%
		206	20-30	55	1.00%	65	5	1.80%	0.52%
		207	30-40	60	1.30%	65	<5	0.30%	200
		208	40-50	70	1.95%	80	10	1.35%	0.18%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	C%
400N	200E	209	litter	15	520	60	15	1.60%	0.18%	litter
		210	0-10	10	270	40	5	2.0%	0.25%	9.1%
		211	10-20	5	250	25	5	2.0%	0.42%	8.0%
400N	225W	212	0-10	5	200	15	<5	2.3%	0.32%	3.9%
		213)	10-20	<2	150	10	<5	2.3%	0.28%)	2.5%
		214)		<2	130	10	5	2.3%	0.26%)	
		215	20-30	2	140	10	5	2.1%	0.17%	1.0%
		216	30-40	2	150	10	5	2.4%	0.13%	1.2%
400N	480W	217	0-5	15	280	55	15	2.6%	0.15%)	5.7%
		218	5-10	5	190	20	5	2.4%	0.24%)	
		219	10-20	2	160	10	<5	0.36%	0.38%	3.1%
		220	20-30	2	120	10	5	0.63%	0.64%	1.0%
		221	30-40	2	160	10	<5	0.50%	0.42%	1.0%
400N	600W	222	0-10	5	130	10	5	1.15%	0.64%	5.3%
		223	10-20	2	95	10	5	1.20%	0.70%	3.1%
		224	20-30	2	100	10	5	1.50%	0.74%	1.0%
400N	700W	225	0-10	10	0.12%	65	5	1.50%	0.70%	8.6%
		226	10-20	10	0.14%	50	5	1.45%	0.61%	8.3%
		227	20-30	15	0.18%	65	10	1.60%	0.60%	7.9%
		228	30-40	15	0.18%	70	10	1.70%	0.54%	6.3%
		229	40-50	20	0.18%	80	10	1.65%	0.42%	3.1%
		230	50-60	25	0.18%	115	10	1.55%	0.35%	3.1%
		231	60-70	25	0.24%	115	5	1.60%	0.19%	2.9%
		232)	70-80	30	0.21%	170	10	1.70%	0.21%)	2.9%
		233)		30	0.22%	170	10	2.2%	8.6%)	
		234	80-90	25	0.12%	165	10	3.6%	7.9%	4.7%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	C%
400N	900W	235)	1-2.5	15	400	110	20	3.6%	6.9%)	12.7%
		236)	2.5-10	15	480	100	20	3.9%	5.5%)	
		237	10-20	10	300	105	20	4.1%	5.8%	5.7%
		238)	20-25	10	300	95	15	5.1%	5.3%)	3.7%
		239)	25-30	10	260	110	10	1.2%	135)	
		240	30-40	10	240	124	15	2.7%	280	2.2%
		241	40-50	20	340	180	10	2.0%	820	1.0%
		242	50-60	15	260	200	15	2.5%	210	1.6%
		243)	60-65	20	340	230	10	3.0%	370)	0.9%
		244)	65-70	20	300	250	15	2.9%	510)	
400N	1125W	245	0-10	10	50	50	70	2.6%	120	15.4%
		246	10-20	10	50	50	70	2.5%	95	13.4%
		247	20-30	10	40	55	75	3.1%	90	6.5%
		248)	30-40	10	40	70	80	3.6%	110)	4.6%
		249)		10	35	65	80	3.5%	110)	
		250	40-50	25	40	95	85	4.6%	140	1.9%
400N	1300W	251	0-10	15	70	40	25	2.2%	105	11.4%
		252)	10-15	10	60	45	40	2.7%	105	8.9%
		253)	15-20	10	60	45	35	3.5%	115	7.4%
		254)	20-25	10	60	50	30	3.3%	120	6.6%
		255)	25-30	10	50	50	40	3.7%	135	3.9%
		256)	30-35	10	50	60	50	3.8%	185)	6.2%
		257)	35-40	10	55	50	40	3.5%	115)	
		258	40-50	15	55	100	40	7.4%	350	5.1%
800N	00W	259	0-10	10	165	150	<5	680	65	10.3%
		260	10-20	5	145	25	<5	520	10	9.5%
		261	20-30	2	155	15	<5	440	5	7.8%
		262	30-40	2	105	10	5	480	15	2.6%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	%C
800N	200W	263	litter	10	210	50	<5	0.14%	100	litter
		264	0-10	5	200	30	5	880	50	4.5%
		265	10-20	5	220	20	<5	440	30	7.6%
		266	20-25	5	200	20	5	600	30	7.4%
800N	400W	267	0-10	5	60	20	<5	460	20	6.9%
		268	10-20	2	55	10	<5	560	15	1.5%
800N	700W	269)	0-5	20	440	55	10	2.5%	0.15%	26.6%
		270)	5-10	10	520	40	10	3.6%	760	12.4%
		271)	10-20	10	560	30	10	.38%	600	8.6%
	Grinder	272)	20-30	(10	740	30	5	4.4%	0.14%)	6.7%
	M & P	273)		(10	740	30	5	4.0%	0.11%)	
		274	30-40	10	960	40	10	5.0%	0.17%	5.7%
		275)	40-50	(10	0.11%	45	10	5.8%	0.29%)	5.3%
		276)		(10	0.11%	45	10	4.2%	0.22%)	
	Grinder	277)	50-60	(15	0.15%	55	10	6.4%	0.34%)	4.6%
	M & P	278)		(15	0.15%	60	10	6.6%	0.36%)	
		279	60-70	20	0.16%	65	10	5.6%	0.27%	2.3%
		280	70-80	15	0.10%	60	10	5.2%	0.14%	1.7%
		281	80-90	10	480	70	5	3.0%	420	1.1%
800N	800W	282	0-10	20	960	60	5	1.30%	0.14%	34.8%
		283	10-20	20	0.10%	50	10	1.45%	0.12%	31.4%
		274	20-30	20	0.16%	60	10	3.0%	0.32%	15.8%
		285	30-40	20	0.20%	60	10	3.6%	0.52%	10.9%
		286	40-50	30	0.26%	75	5	4.1%	0.80%	8.1%
		287	50-60	35	0.25%	75	10	3.9%	0.84%	6.7%
		288	60-70	40	0.24%	90	5	3.5%	0.74%	6.5%

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	%C
800N	1000W	289	0-10	10	125	75	10	2.1%	420	19.0%
		290	10-20	5	100	85	10	2.6%	440	17.5%
		291	20-30	5	100	90	5	3.3%	400	8.4%
		292	30-40	5	100	80	5	3.3%	400	8.2%
		293	40-50	5	100	110	5	3.1%	350	6.7%
		294	50-60	5	105	120	10	3.6%	370	6.5%
1600N	15W	295		20	140	90	5	3.9%	840	litter
		296	0-10	10	100	35	<5	1.70%	180	8.7%
		297	10-20	5	55	20	<5	1.45%	75	6.1%
		298	20-30	5	60	25	5	880	50	3.6%
1600N	200W	299	0-5	35	0.32%	100	5	2.6%	0.84%	12.5%
		300	5-10	30	0.34%	85	10	3.0%	1.10%	9.7%
		301	10-20	35	0.32%	70	5	2.9%	1.20%	3.6%
		302	20-30	40	0.30%	70	5	2.9%	1.00%	3.6%
		303	30-40	45	0.31%	75	5	3.0%	1.05%	3.4%
		304	40-50	55	0.20%	100	10	3.7%	0.42%	1.3%
		305	50-60	60	0.44%	110	10	4.7%	1.50%	1.1%
		306	60-70	60	0.44%	110	10	4.9%	1.25%	2.3%
		307	70-80	60	0.26%	105	10	4.9%	0.70%	3.0%
		308	80-90	65	0.30%	110	10	5.9%	0.96%	3.0%
		309	90-100	65	0.28%	110	10	7.5%	0.76%	2.5%
		310	100-110	60	0.19%	120	10	5.6%	0.26%	1.7%
		311	110-120	65	0.44%	115	10	7.3%	1.30%	1.9%
1600N	600W	312	0-10	5	100	30	<5	0.42%	880	
		313	10-20	5	100	20	10	0.44%	600	
		314	20-30	5	100	30	<5	0.50%	240	
		315	30-40	5	90	25	5	0.54%	105	
		316	40-50	5	85	30	5	0.36%	80	

APPENDIX D.3

Northings	Eastings	Sample No.	Depth (cm)	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	%C
1600N	790W	317	0-10	5	50	20	<5	0.12%	30	
		318	10-20	5	70	15	10	0.13%	20	
		319	20-30	2	30	15	5	0.14%	15	
100 ft from Murchison Mine:		320	0-10	5	25	10	10	0.15%	65	
		321	10-20	2	10	5	<5	800	20	
		322	20-30	2	15	5	10	840	15	
		323	30-40	2	10	5	5	880	10	
On Murchison Mine:		324	0-10	20	500	130	5	1.05%	270	
		325) Grinder		(5	10	20	5	0.20%	25)	
		326) sieved only.		(2	10	10	5	0.16%	20)	

APPENDIX D.4

PARENT ROCK ANALYSES

Northings	Eastings	Sample No.	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm
2400S	500E	361	2	15	10	95	400	5
	180E	362	35	20	45	145	1.80%	210
	200W	363	25	100	190	170	6.2%	490
2425S	250W	360	25	660	100	65	3.1%	340
2400S	350W	364	2	15	20	150	0.28%	35
	520W	365	5	40	60	150	0.84%	100
800S	200E	366	5	100	85	85	0.88%	720
	00W	367	5	65	90	180	1.10%	310
	300W	368	10	80	115	120	2.1%	480
	400W	369	10	340	75	100	1.25%	680
200N	200E	A370) Bull-	40	220	90	65	2.4%	30
		B371) dozer Road	50	50	500	140	1.25%	15
		C372)	55	0.12%	.66%	185	520	15
300N	500E	373	5	80	80	175	0.14%	195
400N	200E	374	5	65	15	230	440	10
	225W	375	2	115	10	140	120	10
	480W	376	2	30	10	210	230	5
	600W	377	<2	80	15	145	560	5
	700W	378	5	80	60	155	0.58%	40
	1125W	379	40	30	125	360	4.7%	320
	1300W	380	15	40	90	135	3.7%	230
800N	00W	381	<2	120	5	125	240	5
	150W	382	260	400	0.26%	140	6.2%	25
	200W	383	5	200	10	150	520	5
	300W	384	<2	15	65	95	0.31%	380

APPENDIX D.4

Northings	Eastings	Sample No	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	Cd ppm	Ba ppm
800N	400W	385	<2	120	35	120	760	5		
	700W	386	10	130	75	115	1.55%	470		
	800W	387	2	65	40	160	0.88%	280		
	1000W	388	<2	40	75	85	3.5%	560		
1600N	15W	389	2	260	15	120	0.54%	10		
	200W	390	30	150	115	85	2.2%	185		
	600W	391	<2	15	25	140	1.00%	195		
		392	<2	15	30	100	1.00%	220		
	790W	393	2	20	45	90	0.92%	125		
Murchison Mine		394	15	620	165	175	0.25%	310		
2400S	200W	395 (Check 363)	25	120	190	200	6.2%	520		
800S	00W	396 (Check 367)	2	50	90	85	1.30%	280		
	400W	397 (Check 369)	5	320	75	100	1.25%	680		
200N	200E	398 (Check 370)	35	200	80	70	2.2%	25		
		Bulldozer road.								
800N	150W	399	260	380	0.26%	135	5.3%	30		
2425S	250W	400	20	520	95	50	3.0%	280	<2	100
400N	900W	401	45	120	25	65	1.45%	10	<2	50
400N	200E	402 Mineralization	0.14%	6.0%	8.8%	175	0.15%	30	250	20
Access	Track	403 Mn deposits	30	210	540	120	0.16%	0.28%	2	250
400N	200E	404 Mineralized "augen"	20	0.96%	0.96%	115	760	40	25	150

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	Wt (g)	Water Soluble					Mn Extraction (Chao.)				
			Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
400N	212	1.60	15	2	3	-	-	-	36	-	-	19
225W	213	1.49	5	-	-	-	-	-	28	-	-	8
	215	1.63	2	0	0	-	-	-	22	-	-	9
	216	1.60	1	1	-	2	-	-	13	-	-	13
400N	225	1.64	2	3	-	40	28	-	425	-	593	430
700W	226	1.62	1	1	-	40	22	-	433	-	652	309
	227	1.56	0	0	-	62	12	-	626	-	465	522
	228	164	-	2	-	63	9	4	724	-	181	466
	229	1.64	0	3	-	66	4	5	712	-	107	115
	230	1.62	2	7	-	90	4	-	1360	-	28	169
	231	1.62	2	2	-	40	5	-	1255	27	3	18
	232	1.65	2	5	-	74	2	-	1095	16	18	18
	234	1.56	2	4	0	30	3	-	536	57	74	5

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	Organic Extraction (peroxide) Cu	Pb	Zn	Fe	Mn	Iron Extraction Cu	Pb	Zn	Fe	Mn	%Clay
400N	212	-	19	-	15	4	-	-	-	150	-	6.55%
225W	213	-	-	-	7	-	-	21	-	134	-	6.34%
	215	-	-	-	2	-	-	-	-	135	-	5.59%
	216	-	-	-	-	-	-	-	-	169	-	5.52%
400N	225	-	95	-	1757	137	-	137	-	23500	245	28.10
700W	226	-	156	-	2643	118	-	165	13	35185	370	26.51
	227	-	154	0	2745	131	-	293	0	37179	449	28.44
	228	-	146	4	343	89	-	274	2	28598	366	31.84
	229	-	139	2	320	137	-	292	3	21646	218	34.61
	230	-	274	12	147	101	-	475	4	14506	91	36.46
	231	-	185	29	88	54	-	369	72	9320	52	39.90
	232	-	276	37	138	57	-	395	34	12182	83	39.22
	234	-	38	35	60	28	-	166	37	3077	27	25.91

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	$Wt_{(g)}$	Clay (Perchloric Extraction)					Silt and Residue (Perchloric Extraction)				
			Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
400N	212	.1048	-	30	3	410	3	-	91	50	2000	31
225W	213	.0944	-	30	3	400	3	-	97	13	2350	34
	215	.0911	-	30	3	370	3	12	123	12	2760	57
	216	.0883	-	30	3	410	3	13	109	19	2800	44
400N	225	.4608	12	250	30	11600	33	-	613	73	40900	128
700	226	.4294	6	250	28	12300	37	-	619	68	53700	173
	227	.4437	6	240	29	12800	38	-	1830	90	76900	333
	228	.5221	9	260	34	14600	43	12	1400	98	73200	543
	229	.5676	9	260	37	15200	40	12	976	98	67100	195
	230	.5706	12	380	42	19400	40	12	988	142	53700	117
	231	.6465	15	380	62	18500	40	12	778	148	45100	93
	232	.6471	15	330	61	17900	48	18	461	194	45900	121
	234	.6042	13	230	38	7100	26	26	308	179	25600	90

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	Wt(g)	Water Soluble					Mn Extraction (Chao.)				
			Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
400N	245	1.61	7	-	5	88	10	-	-	22	586	21
1125W	246	1.53	3	-	-	100	5	-	-	35	523	11
	247	1.58	2	-	2	40	0	-	-	38	147	2
	248	1.59	-	-	-	30	0	-	-	36	35	1
	250	1.54	3	-	5	42	0	-	-	30	75	2
800N	269	1.68	3	0	-	82	98	-	95	73	862	521
700W	270	1.58	4	-	2	87	99	-	163	51	905	403
	271	1.55	5	-	2	86	114	-	213	39	857	345
	272	1.67	1	1	1	55	234	-	337	3	710	719
	274	1.59	-	3	0	40	261	-	435	54	643	833
	275	1.53	4	0	5	35	273	-	654	35	735	1278
	277	1.55	4	0	-	26	56	-	863	3	715	1312
	279	1.53	26	-	3	18	208	-	975	63	576	1242
	280	1.61	4	4	2	13	155	-	558	14	357	613
	281	1.63	4	-	4	38	65	-	209	14	352	606

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	Organic Extraction (peroxide) Cu	Pb	Zn	Fe	Mn	Iron Extraction Cu	Pb	Zn	Fe	Mn	%Clay
400N	245	-	-	-	189	12	-	-	36	3230	-	16.32
1125W	246	-	-	-	137	11	-	-	29	4444	-	6.31
	247	-	-	-	28	6	-	-	42	4494	-	2.64
	248	-	-	-	6	9	-	-	40	2830	-	5.54
	250	-	-	3	6	10	-	-	24	3442	-	3.31
800N	269	-	21	14	2073	149	-	70	25	5357	71	23.21
700W	270	-	-	3	6	123	-	54	27	12089	168	29.90
	271	-	-	-	219	81	-	61	20	13806	135	31.99
	272	-	14	-	168	123	-	61	25	16048	184	34.62
	274	-	-	-	120	123	-	74	3	16855	192	31.68
	275	-	-	-	57	172	-	87	35	17516	247	33.07
	277	-	19	-	79	201	-	116	19	21419	400	39.54
	279	-	16	-	34	185	-	112	14	21895	343	31.41
	280	-	15	-	41	121	-	73	23	16646	261	30.09
	281	-	-	7	17	41	-	48	23	11288	116	17.05

SEQUENTIAL SOIL EXTRACTIONS (ACTUAL SOIL CONCENTRATIONS IN ppm)

Location:	Sample No.	$Wt_{(g)}$	Clay (Perchloric Extraction)					Silt and Residue (Perchloric Extraction)				
			Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
440N	245	.2628	12	30	28	8100	9	-	50	68	22100	37
1125W	246	.0966	10	20	10	2900	-	13	68	85	35300	59
	247	.04170	9	10	6	1300	-	19	63	101	46800	57
	248	.0880	3	15	9	3500	-	19	63	119	55300	63
	250	.0510	3	15	6	2400	-	39	58	175	97400	84
800N	269	.3950	6	130	42	7700	21	12	155	28	18500	48
700W	270	.4724	9	170	28	9800	28	13	228	44	29700	89
	271	.4958	19	170	29	11000	29	13	239	39	31600	84
	272	.5782	6	210	30	13240	36	18	311	48	40100	120
	274	.5037	9	180	28	11900	35	13	396	44	41500	119
	275	.5059	10	190	29	13700	39	20	386	59	48400	163
	277	.6128	10	250	39	18100	55	13	645	77	56100	323
	279	.4806	7	210	33	13700	42	20	654	216	55600	294
	280	.4844	6	190	31	13000	40	19	609	143	57800	329
	281	.2799	3	110	21	7100	18	25	196	110	38700	117

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (←→TOTAL).

Location	Sample No.	Water Extraction (H_2O)					Mn Extraction (Chao)					Organic Extraction (Peroxide)				
		Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
400N 225W	212	100	1.1	5.4	-	-	-	20.2	-	-	33.3	-	10.7	-	0.6	7.0
	213	100	-	-	-	-	-	15.9	-	-	17.8	-	-	-	N/S	-
	215	14.3	-	-	-	-	-	12.6	-	-	18.4	-	-	-	-	-
	216	7.1	-	-	-	-	-	8.5	-	-	21.7	-	-	-	-	-
	Total ppm	23	3	3	2	-	-	99	-	-	49	-	19	-	24	4
400N 700W	225	14.3	0.2	-	N/S	2.8	-	27.9	-	N/S	43.0	-	6.2	-	2.2	13.7
	226	14.3	-	-	N/S	2.1	-	26.7	-	N/S	30.0	-	9.6	-	2.5	11.5
	227	-	-	-	N/S	N/S	-	19.9	-	N/S	34.8	-	4.9	-	2.1	8.7
	228	-	N/S	-	N/S	N/S	16.0	25.9	-	N/S	31.2	-	5.2	2.9	N/S	5.9
	229	-	N/S	-	N/S	N/S	19.2	29.7	-	N/S	16.2	-	5.8	1.4	N/S	19.3
	230	7.7	N/S	-	N/S	N/S	-	38.9	-	N/S	32.4	-	7.8	6.0	N/S	19.3
	231	6.9	N/S	-	N/S	1.9	-	41.8	8.0	N/S	6.9	-	6.2	8.6	N/S	20.6
	232	5.7	N/S	-	N/S	N/S	-	42.1	4.7	N/S	5.5	-	10.6	10.8	N/S	17.3
	234	4.9	N/S	-	N/S	1.7	-	41.2	16.5	N/S	2.8	-	2.9	10.1	N/S	15.6
	Total ppm	11	27	-	505	89	9	0.72%	100	0.21%	0.21%	-	0.15%	119	0.82%	852

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (←→TOTAL)

Location	Sample No.	Iron Extraction					Clay Extraction (perchloric)					%Clay
		Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn	
400N 225W	212	-	-	-	5.7	-	-	16.9	5.4	15.6	5.3	6.55
	213	-	11.9	-	4.6	-	-	17.0	3.0	13.8	6.7	6.34
	215	-	-	-	4.1	-	-	17.1	2.4	11.3	6.1	5.59
	216	-	-	-	5.0	-	-	19.6	2.7	12.1	5.0	5.52
	Total ppm	-	21	-	588	-	-	120	12	0.16%	12	
400N 700W	225	-	9.0	-	30.0	24.5	85.7	16.4	29.1	14.8	3.3	28.10
	226	-	10.2	11.4	33.7	34.0	85.7	15.4	24.6	11.8	3.6	26.51
	227	-	9.3	-	28.6	29.9	85.7	7.6	24.4	9.8	2.5	28.44
	228	-	9.8	1.4	24.4	24.4	36.0	9.3	24.6	12.5	2.9	31.84
	229	-	12.2	2.1	20.7	30.7	34.6	10.8	26.4	14.6	5.6	34.61
	230	-	13.6	2.0	16.5	17.4	46.2	10.9	21.0	22.1	7.8	36.46
	231	-	13.3	21.3	12.7	19.8	51.7	12.7	18.3	25.3	15.2	39.90
	232	-	15.2	9.9	16.0	25.2	42.9	12.7	17.8	23.5	14.6	39.22
	234	-	12.8	10.7	8.6	15.1	31.7	17.7	11.0	19.8	14.5	25.91
	Total ppm	-	0.26%	165	18.52%	0.19%	97	0.26%	361	12.94%	345	

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (←→TOTAL)

Location:	Sample No.	Silt and Residue Extraction (perchloric) Cu	Pb	Zn	Fe	Mn	%Carbon	Total Concentration on Summation (for each individual sample) Cu_t	Pb_t	Zn_t	Fe_t	Mn_t
400N 225W	212	-	51.1	89.3	78.2	54.4	3.9	15	178	56	0.26%	57
	213	-	55.1	97.0	81.3	75.6	2.5	5	176	100	0.29%	45
	215	85.7	70.3	97.6	84.5	75.5	1.0	14	175	126	0.33%	49
	216	92.9	71.2	97.3	82.9	73.3	1.2	13	153	112	0.34%	60
	Total ppm	25	420	94	1.00%	146		43	529	3.14	1.22%	211
400N 700W	225	-	40.2	70.9	52.2	12.8	8.6	14	0.15%	103	7.84%	0.10%
	226	-	38.1	64.0	51.4	16.8	8.3	7	0.16%	114	10.45%	0.10%
	227	-	58.3	75.6	59.1	22.2	7.9	7	0.314%	119	13.02%	0.15%
	228	48.0	50.0	71.0	62.6	36.2	6.3	25	0.28%	138	11.70%	0.15%
	229	46.2	40.7	70.0	64.3	27.5	3.1	26	0.24%	140	10.44%	709
	230	46.2	28.2	71.0	61.1	22.4	3.1	26	0.35%	200	8.79%	522
	231	41.4	25.9	43.7	61.7	35.5	2.9	29	0.30%	338	7.31%	262
	232	51.4	17.7	56.7	60.2	36.8	2.9	35	0.26%	342	7.62%	329
	234	63.4	23.7	51.7	71.3	50.3	4.7	41	0.13%	346	3.59%	179
	Total ppm	92	0.80%	0.11%	48.21%	0.18%		203	2.18%	0.18	80.76%	0.70%

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (⟷TOTAL).

Location	Sample No.	Water Extraction (H_2O)					Mn Extraction (Chao)					Organic Extraction (Peroxide)				
		Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn	Cu	Pb	Zn	Fe	Mn
400N 1125W	245	36.8	-	3.1	N/S	11.2	-	-	13.8	1.7	23.6	-	-	-	N/S	13.5
	246	11.5	-	-	N/S	5.8	-	-	22.0	1.2	12.8	-	-	-	N/S	12.8
	247	6.7	-	1.0	N/S	-	-	-	20.1	N/S	3.1	-	-	-	N/S	9.2
	248	-	-	-	N/S	-	-	-	17.6	N/S	1.4	-	-	-	N/S	12.5
	250	6.7	-	2.1	N/S	-	-	-	12.3	N/S	2.1	-	-	1.2	N/S	10.4
	Total ppm	15	-	12	300	-	-	-	161	0.14%	37	-	-	3	366	48
800N 700W	269	14.3	-	-	N/S	10.8	-	20.2	40.1	2.5	57.4	-	4.5	7.7	6.0	16.4
	270	15.4	-	1.2	N/S	10.9	-	26.5	32.9	1.7	44.3	-	-	1.9	N/S	13.5
	271	13.5	-	1.6	N/S	14.5	-	31.2	30.2	1.5	43.8	-	-	-	N/S	10.3
	272	14.3	N/S	1.0	N/S	16.7	-	36.1	2.8	1.0	51.4	-	1.5	-	N/S	8.8
	274	-	N/S	-	N/S	16.3	-	39.5	41.9	N/S	52.1	-	-	-	N/S	7.7
	275	11.8	-	3.1	N/S	12.4	-	50.3	21.5	N/S	58.1	-	-	-	N/S	7.8
	277	14.8	-	-	N/S	2.3	-	45.4	2.2	N/S	56.7	-	1.0	-	N/S	8.4
	279	49.1	-	1.0	N/S	9.0	-	48.7	19.1	N/S	54.0	-	N/S	-	N/S	8.0
	280	13.8	N/S	1.0	N/S	10.3	-	37.2	6.6	N/S	40.9	-	1.0	-	N/S	8.1
	281	12.5	-	2.2	N/S	6.7	-	37.1	7.8	N/S	62.9	-	-	3.9	N/S	4.3
	Total ppm	58	8	19	480	0.16%	-	0.56%	349	0.61%	0.79%	-	85	24	0.28%	0.13%

N/S = Not significant, equivalent to <1%.

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (←→TOTAL).

Location:	Sample No.	Iron Extraction Cu	Pb	Zn	Fe	Mn	Clay Extraction (perchloric) Cu	Pb	Zn	Fe	Mn	%Clay
400N 1125W	245	-	-	22.6	9.4	-	63.2	37.5	17.6	23.6	10.1	16.32
	246	-	-	18.2	10.2	-	38.5	22.7	6.3	6.7	-	6.31
	247	-	-	22.2	8.5	-	30.0	13.7	5.2	2.5	-	2.64
	248	-	-	19.6	4.6	-	13.6	19.2	4.4	5.7	-	5.54
	250	-	-	9.9	3.3	-	6.7	20.5	2.5	2.3	-	3.31
	Total ppm	-	-	171	1.84%	-	37	90	59	1.82%	9	
800N 700W	269	-	14.9	13.7	15.5	7.8	28.7	27.6	23.0	22.3	2.3	23.21
	270	-	8.8	17.4	23.0	18.5	34.6	27.6	18.1	18.6	3.1	29.90
	271	-	8.9	15.5	24.0	17.1	51.4	24.9	22.5	19.1	13.7	31.99
	272	-	6.5	23.4	22.8	13.1	21.4	22.5	28.0	18.8	2.6	34.62
	274	-	6.7	2.3?	23.7	12.0	40.9	16.4	21.7	16.7	2.2	31.68
	275	-	6.7	21.5	21.8	11.2	29.4	14.6	17.8	17.0	1.8	33.07
	277	-	6.1	13.8	22.2	16.7	37.0	13.2	28.3	18.8	2.3	39.54
	279	-	5.6	4.3	23.9	14.9	13.2	10.5	10.0	14.9	1.8	31.41
	280	-	4.9	10.8	18.9	17.4	20.7	12.7	14.6	14.8	2.7	30.09
	281	-	8.5	12.8	19.6	12.0	9.4	19.5	11.7	12.3	1.9	17.05
	Total ppm	-	750	214	15.29%	0.21%	85	0.18%	310	11.92%	343	

N/S = Not significant, equivalent to <1%.

EXPRESSED AS PERCENTAGE OF TOTAL CONCENTRATION IN EACH SAMPLE (⟷TOTAL).

Location:	Sample No.	Silt and Residue Extraction (perchloric) Cu	Pb	Zn	Fe	Mn	%Carbon	Total Concentration on Summation (for each individual sample) Cu_t	Pb_t	Zn_t	Fe_t	Mn_t
400N 1125W	245	-	62.5	42.8	64 4	41.6	15.4	19	80	159	3.43%	89
	246	50.0	77.3	53.5	81.3	68.9	13.4	26	88	159	4.34%	86
	247	63.3	86.3	53.4	88.6	87.7	6.5	30	73	189	5.28%	65
	248	86.4	80.8	58.3	89.6	86.3	4.6	22	78	204	6.17%	73
	250	86.7	79.5	72.0	94.2	87.5	1.9	45	73	243	10.34%	96
	Total ppm	90	302	548	25.69%	300		142	342	954	29.56%	409
800N 700W	269	57.1	32.9	15.4	53.5	5.3	26.6	21	471	182	3,46%	908
	270	50.0	37.1	28.4	56.5	9.8	12.4	26	615	155	5.26%	910
	271	35.1	35.0	30.2	54.9	10.7	8.6	37	683	129	5.76%	788
	272	64.3	33.3	44.9	57.0	8.6	6.7	28	934	107	7.05%	0.14%
	274	59.1	36.0	34.1	58.4	7.4	5.7	22	0.11%	129	7.11%	0.16%
	275	58.8	29.7	36.2	60.2	7.4	5.3	34	0.13%	163	8.04%	0.22%
	277	48.1	33.9	55.8	58.2	13.5	4.6	27	0.19%	138	9.64%	0.24%
	279	37.7	32.7	65.7	60.6	12.8	2.3	53	0.20%	329	9.18%	0.23%
	280	65.5	40.6	67.1	65.8	21.9	1.7	29	0.15%	213	8.79%	0.15%
	281	78.1	34.8	61.5	67.3	12.1	1.1	32	563	179	5.75%	963
	Total ppm	166	0.38%	808	41.80%	0.17%		309	1.11%	0.17%	70.02%	1.50%

N/S = Not significant, equivalent to <1%.